Module 5
Detailed Analysis of Alternatives

Contents

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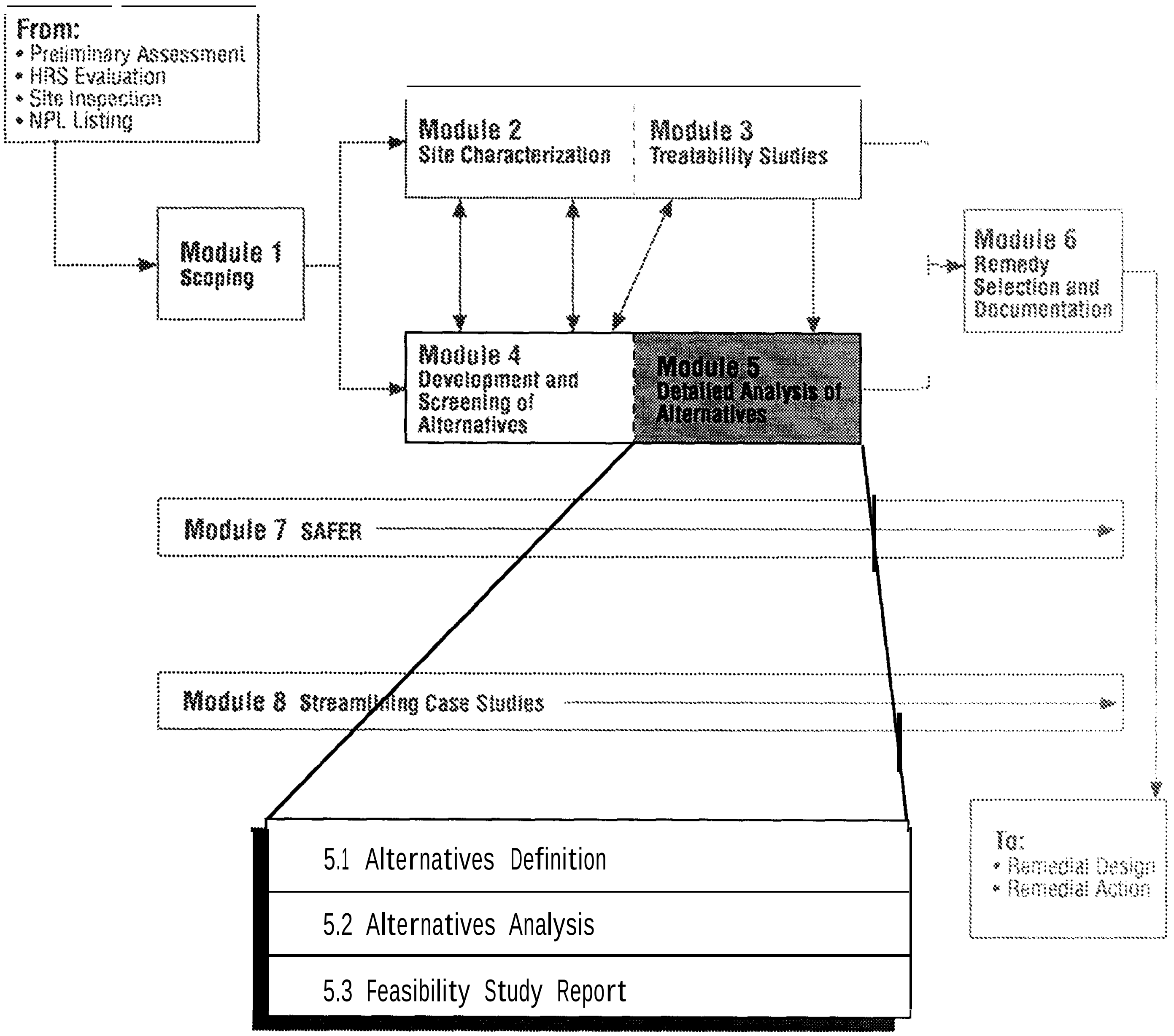


Module 5
Detailed Analysis of Alternatives

Background

The detailed analysis of alternatives consists of analysis and presentation of the relevant information needed for enabling decisionmakers to select a site remedy. However, this is not the actual decisionmaking process; the decisionmaking process is included as part of Module 6. The detailed analysis of alternatives is conducted after alternatives have been developed and screened (Module 4). The goal of the evaluation is to demonstrate how alternatives meet the following seven National Oil and Hazardous Substances Pollution Contingency Plan (NCP) [40 CFR 300.430(e)(2)] requirements:

- Overall protection of human health and the environment
- Compliance with applicable or relevant and appropriate requirements (ARARs)
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and/or volume of wastes or contaminants through treatment
- Short-term effectiveness
- Implementability
- Cost (plus 50 to minus 30 percent)

State and community acceptance, the last two criteria, are evaluated finally during Remedy Selection and Documentation in Module 6.

Preparation of the Feasibility Study (FS) report is the last step in the FS process. As with the Remedial Investigation (RI) report, the FS report is most easily developed through a series of technical memoranda. Each technical memorandum is shared with and commented on by the extended project team, which simplifies report production and facilitates extended project team acceptance.

Organization

Module 5 is divided into three submodules

5.1 Alternatives Definition
5.2 Alternatives Analysis
5.3 Feasibility Study Report

Documents

Progress and results of the detailed analysis are communicated with stakeholders in informal and formal documents. The document developed as a result of the activities described in Module 5 is the following:

(1) The Feasibility Study report.

Submodule 5.1 Alternatives Definition

Detailed Analysis of Alternatives

- **5.1 Alternatives Definition**
- 5.2 Alternatives Analysis
- 5.3 Feasibility Study Report

5.1 Alternatives Definition

- **Defining Alternatives**
- **Developing Contingency Plans**
- **Developing Monitoring Plans**

Submodule 5.1 Alternatives Definition

Background

Although the alternatives and their associated contingency plans were defined as part of the initial development and screening of alternatives, those selected as the most promising typically need to be defined in more detail before evaluation. This is especially true for cost evaluation. The information developed to define alternatives at this stage in the RI/FS process generally includes preconceptual design calculations; process flow diagrams; sizing of key process components; preliminary site layouts; and a discussion of limitations, assumptions, and uncertainties concerning each alternative.

Organization

Submodule 5.1 discusses the following:

- Defining Alternatives
- Developing Contingency Plans
- Developing Monitoring Plans

In addition, more detailed information is provided in the following notes:

- Note A−Example Alternative for Detailed Analysis
- Note B−Example Evaluation of Deviations and Contingency Plans for Detailed Analysis
- Note C−Example Reasonable Deviations and Contingency Plans

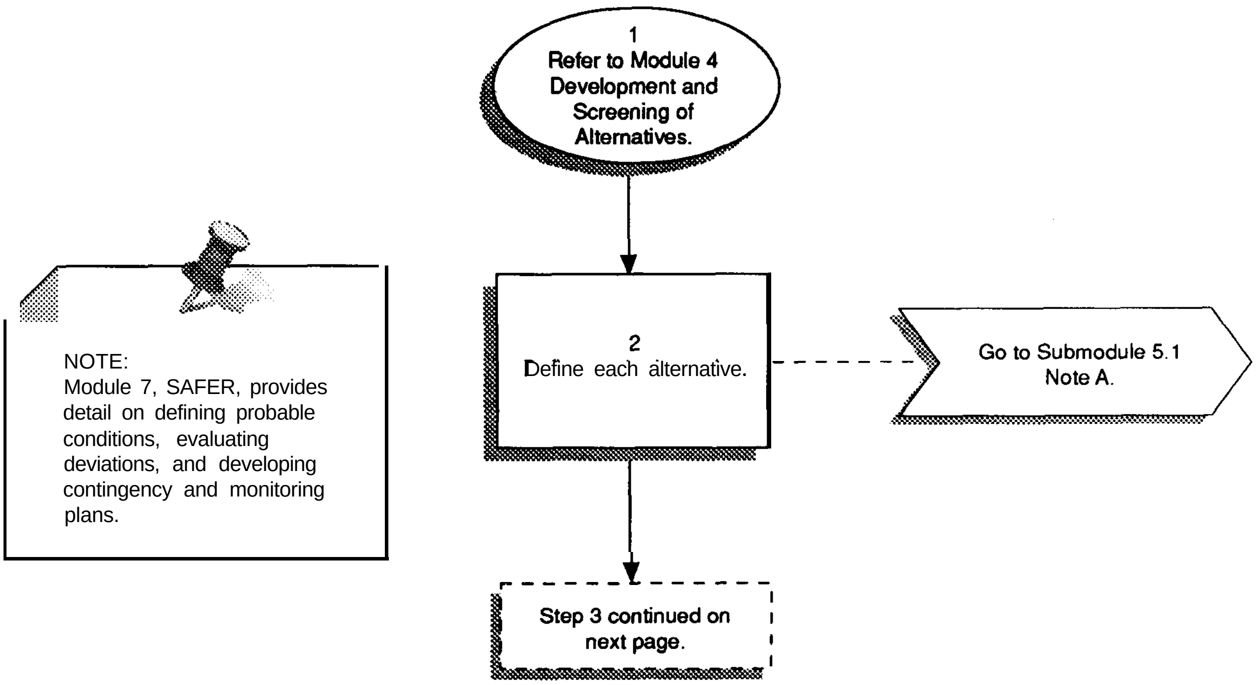
Sources

1. U.S. EPA, October 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, Interim Final, EPA/540/G89/004, OSWER Directive 9356.3-01.

2. CH2M HILL, June 1993, *Baldwin Park Operable Unit Feasibility Study Report, San Gabriel Basin, Los Angeles County, California*, Prepared for U.S. Environmental Protection Agency, Region IX, EPA Contract No. 68-W9-0031.

3. CH2M HILL, June 1993, *Conjunctive Use Feasibility Study, San Gabriel Basin, Los Angeles County, California*, Prepared for Metropolitan Water District of Southern California, Main San Gabriel Basin Watermaster, Upper San Gabriel Valley Municipal Water District, and San Gabriel Valley Municipal Water District.

Submodule 5.1 Alternatives Definition



Step 1. Refer to Module 4, Development and Screening of Alternatives.

Step 2. **Define each alternative.** The alternatives were defined prior to screening, but only sufficiently to support the screening step. For detailed alternatives analysis, the concepts must be examined to provide definition for each. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the NCP refer to this process as defining the alternatives. In the detailed analysis, the alternatives are evaluated against seven criteria (and later against two additional criteria). The first seven criteria are technical in nature:

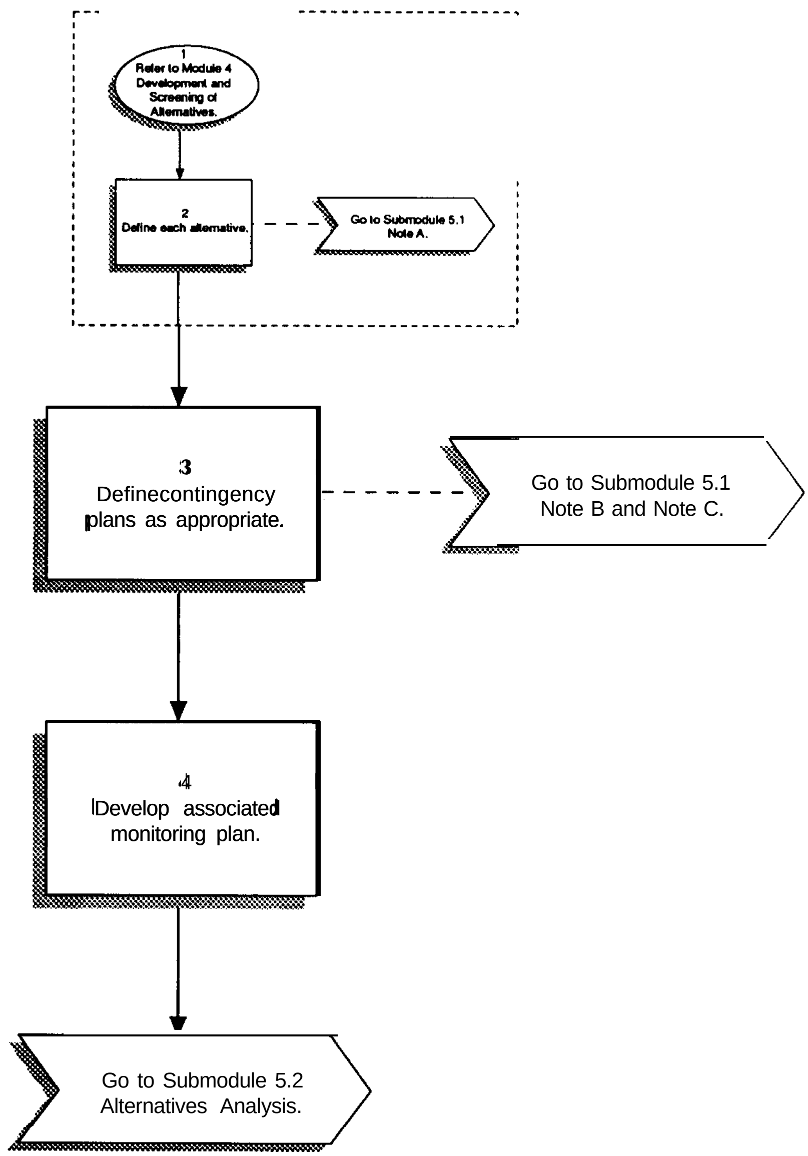
- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and/or volume of wastes or contaminants through treatment
- Short-term effectiveness
- Implementability
- Cost (plus 50 to minus 30 percent)

To evaluate an alternative against these criteria, details will be required for specificity about how the alternative might be accomplished. The level of detail should be comparable to a preconceptual design of the remedial approach. For example, in order to assess whether a precipitation process can be designed to treat metals at certain levels (and to certain levels), completion of a preconceptual level design of a system may be necessary for exploring different process options and combinations of process options. In this process, the alternative changes from a mere idea to a conceptual approach or a fairly specific *example* of how the alternative might work in practice. It thus becomes specific enough to make predictions about protectiveness, achieving ARARs, effectiveness, implementability, and cost. Note that no matter how specific an alternative may become during definition, it is still only an *example* of how the alternative might be designed and implemented. Each alternative is used only for differentiation and comparison. Actual remedial design will occur following remedy selection.

The difficulty and time required for the alternatives definition step of the RI/FS process often is underestimated. A great deal of engineering time is typically required. The primary reason for aggressive screening of alternatives (see Module 4, Development and Screening of Alternatives) is to ensure that only viable alternatives are developed in detail.

Each alternative is defined to meet the *probable* conditions, as reflected in the site model. The alternatives essentially assume that the probable conditions are the conditions that will be met in the field during remediation. (The likelihood that different conditions will be found is addressed separately; see Step 3.) The alternatives specifically, as defined to meet the probable conditions, are analyzed in detail in the final steps of the FS. The reasonable deviations from the probable conditions, the contingency plans to meet those deviations, and the implications (cost and other) of the contingency plans are modifying factors that are also considered in the detailed analysis and in the decisionmaking process. The alternatives are focused on the probable conditions so that project staff (e.g., the engineers, regulatory specialists, and risk assessors) have a specific alternative to define. An example of a defined alternative is presented in Submodule 5.1, Note A.

Submodule 5.1 Alternatives Definition (cont.)



Step 3. **Define contingency plans, as appropriate**. During alternatives definition, the internal project team (e.g., engineers, regulatory specialists, and risk assessors) will consider each of the reasonable deviations from the probable site conditions as well as their potential impacts (see Submodule 4.3, Alternatives Assembly) on each of the alternatives. Some of the deviations will not affect every alternative; but, it is necessary in the FS to explicitly consider each potential impact.

A contingency plan should be considered for those impacts that are significant. If no contingency plan is possible for meeting the deviation, this should be noted during evaluation of the alternative. If no contingency plan can be identified, the alternative probably is not a good candidate for selection. Screening of alternatives is also discussed in Submodule 4.4.

The contingency plans must be defined in order to perform the detailed analysis; but, they do not have to be defined to the same level of detail as the alternatives. Three considerations in defining each contingency plan are as follows:

- Implementability: whether it is reasonable to assume that a modification of the alternative (i.e., a contingency plan) can be implemented and relied on to work effectively

- Protectiveness: whether the alternative contingency plan will provide equal or greater protectiveness and achieve ARARs as effectively as the (base) alternative

- Cost: the cost impacts of having to implement the contingency plan. Precision is not the goal. The likelihood of the deviation is low (otherwise it would be the probable condition), and the alternative can be implemented as defined in Step 2, without resorting to the contingency plan. The approximate level of cost impact should be known in the event that the contingency plan has to be implemented.

Examples of contingency plans are presented in Submodule 5.1, Note B and Note C.

Step 4. **Develop associated monitoring plan**. A monitoring plan should be identified and defined for each reasonable deviation that could affect implementation of one or more of the alternatives. The monitoring plans are one of the most important aspects of the alternatives and should be defined to the same level of detail as the alternatives, which is necessary for two reasons: (1) the monitoring plans will be implemented and relied upon for all alternatives and (2) the cost impacts of the monitoring plans must be known to plus 50 to minus 30 percent, because they are a part of each alternative.

The purposes for the monitoring plans are: (1) to evaluate whether actual site conditions match probable site conditions and (2) to evaluate technology performance. Primary indicators of conditions and performance are selected for observation. Expected values for these parameters are established for both the probable conditions and expected technology performance as well as for the reasonable deviations. These expected values are then used to determine when a deviation or failure of a technology has occurred. Submodule 5.1, Note B, provides an example monitoring plan, and Submodule 7.3 provides more information on monitoring plans.

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<u>Note A</u>. **<u>Example Alternative for Detailed Analysis</u>.** This example of a defined alternative is taken from the final EPA FS of a major National Priorities List (NPL) site in California. Use of the excerpt is illustrative and does not necessarily represent any activity currently under way.

The Baldwin Park operable unit (OU) is part of the much larger San Gabriel Basin groundwater contamination problem. The groundwater at various areas in the basin is contaminated, typically with volatile organic compounds (VOCs) and, in some places, with nitrate and/or metals. In this example, the basic approach to remediation has been determined: extraction followed by treatment, distribution, and use as drinking water.

Baldwin Park is a groundwater OU that has been on the NPL since 1979 because of its contamination−primarily by VOCs. The objective of the Baldwin Park OU is to inhibit contaminant migration from more highly contaminated portions of the aquifer to less contaminated areas or depths, to reduce the impact of continued contaminant migration on downgradient water supply wells, and to protect future uses of less contaminated and uncontaminated areas. Attaining this objective will require extraction of large quantities of groundwater from contaminated portions of the basin, reversing the trend of the 1980s when water producers in the basin moved production wells out of contaminated areas or depths in search of clean water. A secondary objective is to remove contaminant mass from the aquifer.

The level of effort required in defining the alternatives prior to the detailed evaluation often is underestimated. Even though the alternatives as defined in the FS are only specific examples of how an alternative may be implemented in practice, and even though the actual remediation will almost certainly differ significantly from the alternative as defined in the FS, reasonable specificity is still necessary in the definition of alternatives. Detailed evaluations of implementability, effectiveness, and (especially) cost have to be based on specific implementation scenarios; they cannot be based on vague concepts. Each of the alternatives should be defined to the same level of detail to facilitate balanced comparisons between remedial approaches.

This example uses excerpts from Section 11 (Remedial Alternative Development and Description) of the FS. Although four alternatives were developed, this example presents only the description of Alternative 1. Background information is provided in a discussion of the project approach to managing uncertainty and in a summary of all four alternatives. The defined alternative is then presented.

Submodule 5.1, Note B, is a companion to this note and provides a summary of the identified reasonable deviations and contingency plans for Alternative 1.

The following five aspects from this example should be noted.

- The level of definition is much greater than would be required simply to communicate the essentials of the alternative to the extended project team and stakeholders. In addition to communicating the essentials, the level of definition has to be sufficient to meet the needs described in the following bullets.

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- The level of definition is sufficient to allow the regulatory specialists to determine the likelihood of achieving ARARs through implementation of the alternative.

- The level of definition is sufficient to allow the risk assessors to determine the likelihood of achieving human health and environmental protectiveness through implementation of the alternative.

- The alternative has been resolved in sufficient detail that an engineer can predict with reasonable assurance the implementability, effectiveness (including effectiveness in reducing toxicity, mobility, and/or volume of wastes or contaminated media), and reliability of the alterative if implemented as envisioned and if the probable conditions are actually met in the field.

- The level of definition is sufficient to allow an engineer to identify all major cost items in the following categories. (It is important to note that for any particular cost estimate just a few of these categories will determine, to a large degree, the total cost. If is not necessary to complete a plus 50 to minus 30 percent cost estimate for each of these categories.).

  - design
  - permitting
  - procurement
  - bonding
  - insurance
  - legal services
  - rent
  - labor
  - materials
  - travel
  - equipment (purchase)
  - equipment (rental)
  - special equipment that will have to be fabricated (e.g., treatment systems)
  - specialty subcontractors
  - mobilization
  - utilities
  - site access
  - relocation of affected population
  - land acquisition and site development
  - utility relocation
  - buildings
  - site security
  - health and safety
  - services during construction
  - sampling and analysis (e.g., compliance, health and safety, investigation during remediation, fugitive emissions monitoring and control)
  - monitoring for deviations and effectiveness (monitoring plan)

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- decontamination
- management of wastes
- reports during remediation
- community relations during remediation
- startup
- management of treatment residuals
- transportation
- demobilization
- operation and maintenance
- contingencies
- profit (contractors)

Few of these costs have to be estimated to a high degree of accuracy. However, any of these costs that will be significant in the overall cost of an alternative must be considered in the cost estimate.

The level of definition is sufficient to allow the decisionmakers and stakeholders to judge the acceptability of the alternative from their perspectives.

This is an unedited excerpt from the *Baldwin Park Operable Unit Feasibility Study Report, San Gabriel Basin, Los Angeles County, California* (CH2M HILL, 1993).

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Section 11

Remedial Alternative Development and Descriptions

This section describes a "no-action" alternative and four remedial alternatives developed to meet the remedial response objectives of the Baldwin Park OU (defined in Section 6). The remedial alternatives are described in sufficient detail to allow an evaluation of cost, effectiveness, and ease of implementation. These three criteria are the primary Superfund evaluation criteria, described in Section 12.

The final configuration of the remedial alternative selected for implementation will be based on requirements included in the record of decision (ROD) and on additional information acquired post-ROD. Some project details described in this FS (e.g., treatment facility locations, identification of purveyors that would accept treated water, pipeline routes) are based on preliminary research and analysis, and may change. These details are provided only to estimate costs and to compare remedial alternatives; they are not offered as a final design.

The alternatives in the FS are only specific examples of the overall approach being evaluated. The ROD also focuses on an overall approach; the details are worked out later during RD.

11.1 Remedial Alternative Development

Section 6 of this FS concludes with a list of remedial technologies and process options believed capable of achieving the OU remedial objectives.

Sections 7, 8, and 9 describe the remedial technologies in more detail. Section 7 provides recommendations on the rate and locations of groundwater extraction, based on the remedial objectives; the extent of contamination; and the results of computer modeling simulating the effects of various extraction configurations on the movement of groundwater and contamination in the OU area. Section 8 provides a recommendation that air stripping with off-gas control be used for removal of VOCs from groundwater. Section 9 describes three options for distributing groundwater extracted and treated as part of a remedial alternative, but does not provide recommendations for any of the three options.

This section combines the extraction, treatment, and water use components described in Sections 7, 8, and 9 into four remedial alternatives, as summarized in Table 11-1. Each of the four remedial alternatives includes groundwater monitoring, groundwater extraction, air stripping for VOC removal, vapor-phase granular activated carbon (VGAC) adsorption for off-gas control, and one or a combination of the three water use options. The differences between alternatives are in extraction rate and configuration (i.e., project size) and water use.

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The alternatives include one of two extraction schemes: either the configuration described in Section 7 that includes extraction in all three subareas (total extraction of 29,000 gpm), or a less aggressive configuration that includes extraction in only two of the three subareas (total extraction of 19,000 gpm). The less aggressive extraction option is included because of the potential difficulties of distributing the last increment of 10,000 gpm of water, and the discretion available in an interim action to select a remedy that minimizes institutional obstacles that might delay implementation.

Alternatives usually are based on some assumptions.

All four alternatives assume air stripping with VGAC adsorption for VOC removal (and for off-gas control), although, as described in Section 8.1.3.2, LGAC may be equally effective for some mixes of contaminants. Assumptions about the number and location of treatment facilities are made, for the most part, to minimize pipeline and pumping costs, even if vacant land parcels at the assumed treatment facility locations have not been identified. These assumptions about treatment facility locations differ from assumptions made in earlier evaluations in which a single "centralized" treatment facility was assumed (i.e., extracted groundwater was assumed to be piped from multiple extraction locations to a single treatment facility, and then to one or many delivery locations). Centralized alternatives offer the advantage of blending capacity (a higher than expected contaminant concentration at one or a few extraction locations could be blended down with groundwater extracted from other locations, lessening the risk that the treatment facility capacity would be exceeded), but at the expense of higher pipeline and pumping costs.

One alternative (Alternative 4), however, assumes a single centralized treatment facility because of Metropolitan's preference for operating a single facility. The higher costs do not disqualify this arrangement because Metropolitan may fund a portion of the costs as "enhancement costs" (described in Section 12.7.1.3).

Limiting the number of alternatives that will be evaluated in detail.

The remaining variable that must be specified to define each remedial alternative is the water use option(s). The number of possible water use options is large, since the groundwater extracted from each of the seven extraction locations or from combinations of locations could be distributed to any or a combination of the water use options described in Section 9. To limit the number of alternatives, analyses were completed to screen out the less likely water use options. The results of the screening exercise are presented in Section 11.1.1.

Abbreviated sections.

11.1.1 Alternative Development Options . . .

11.1.2 Alternative Development Options–Cost Comparison . . .

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11.1.3 Remedial Alternatives

Alternatives 1, 2, and 3 all include distribution of treated water from Subarea 3 to water purveyors for local use. The alternatives differ, however, in the disposition of treated water from the other subareas. Alternative 1 assumes that treated water from Subarea 1 is also distributed to water purveyors for local use. Alternative 2 assumes that treated water from Subareas 1 and 2 is distributed to a combination of water purveyors for local use and aquifer recharge. Alternative 3 assumes that treated water from Subareas 1 and 2 is distributed to Metropolitan for export out of the San Gabriel Basin year-round (although a secondary recipient may potentially receive water during off-peak periods).

Alternative 4 assumes that treated water from all three subareas is distributed to Metropolitan for export year-round (although a secondary recipient may receive water during off-peak periods).

In addition, Alternatives 3 and 4 include recharge of imported surface water during off-peak periods (fall and winter months) so that net export out of the San Gabriel Basin does not increase.

Alternatives 1, 2, and 3 also include reducing extraction at existing water supply wells located outside of Subarea 3 to provide additional contaminant migration control and to offset the treated water that purveyors would receive.

Subsections 11.2, 11.3, 11.4, 11.5, and 11.6 describe the no-action alternative and the four remedial alternatives in more detail. Subsection 11.7 describes components of the remedy incorporated to improve the ability of the OU to respond to uncertainty in design parameters. Incorporating these recommendations should decrease the risk that unexpected conditions (e.g., higher than expected contaminant concentrations) would interfere with the ability of the remedy to meet remedial objectives. Other potential modifications to the treatment component of the remedy, which may reduce total cost, are described in Section 8.4.

11.2 No-Action Alternative

A no-action (or no active response) alternative is required by the NCP to provide a baseline for comparison of other alternatives. In a no-action alternative, no remedial measures are taken to control migration from or within the OU area of contamination.

The no-action alternative would include a monitoring program to provide early warning of increasing contaminant concentrations at existing, active production wells downgradient of the OU area of contamination.

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The monitoring program would provide data to help project when contaminants in downgradient production wells may increase to such a level that installation of new wellhead treatment or modification of existing wellhead treatment will be required. At present, only three clusters of production wells are active within approximately 1 mile of the downgradient end of the OU area of contamination (SGVWC's B4 and B6 clusters and LPVCWD's cluster [see Distribution Points F, G, and D in Figure 9-4]). Two of the three clusters are located within several hundred feet of each other. For cost-estimating purposes, it is assumed that three new monitoring wells would be required to meet the objectives of the monitoring program.

Assumptions.

11.3 Alternative 1

Alternative 1 includes the year-round continuous extraction of 19,000 gpm (27.4 million gallons per day [mgd] or 30,700 ac-ft/yr). The 19,000-gpm extraction rate is the recommended rate needed to meet OU migration control objectives in contaminant Subareas 1 and 3 only (see Section 7 for a description of the flow evaluations). It is assumed that the extracted water would be treated to drinking water standards (MCLs) at four treatment plants and conveyed to local water purveyors at six distribution locations at a constant rate and pressure. Four different purveyors are represented at these six locations, which represent a subset of the 18 potential distribution locations identified in Section 9.2. The assumed locations, volumes, and pressures at which the purveyors would receive water are based on preliminary discussions with purveyors, as described in Section 11.3.5.

Figure 11-7 provides a summary of the extraction, treatment, conveyance, and distribution facilities associated with Alternative 1. Details on each of the major components of Alternative 1 are provided in the following subsections.

11.3.1 Alternative 1 Groundwater Monitoring Program

A monitoring program will be an essential component of any remedial alternative. The monitoring program is required to provide additional data on the nature and extent of contamination in the OU area, verify the influent estimates, detect deviations from the influent estimates, and monitor performance of the alternative.

Specifically, the objectives of the recommended monitoring program are to:

Monitoring Program for identifying need to implement contingency plans.

- Confirm or revise contaminant influent concentration estimates that will be used in the design of the OU treatment facilities.

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- Provide an early warning network so that changes in the groundwater flow regime or contaminant concentrations that may require modifications in extraction rates, well locations, or treatment methods are identified in time to institute the necessary facility and operational changes.

- Evaluate the effectiveness of the OU in controlling contaminant migration within and downgradient of VOC contamination in the OU area. This is especially important downgradient of Subarea 3 (the downgradient subarea). To achieve this objective, water levels and water quality will require monitoring before and after implementation of the remedy ("baseline conditions"). The data will be used to help determine the need for and nature of future remedial actions.

The recommended monitoring program is summarized in this section and described in Appendix E. The monitoring program consists of bimonthly to semiannual sampling of existing production wells and of existing and new monitoring wells. The following numbers and types of wells are included in the monitoring program:

- Twenty-four existing inactive and active production wells, including the two existing wells recommended as OU extraction wells

- Five existing "standard" monitoring wells

- One existing multiport (MP) monitoring well

- Two recommended MP monitoring wells

- Seven recommended three-well monitoring well clusters

- Three recommended sets of three piezometers (near extraction Clusters 4, 5, and 6)

- Five recommended new extraction wells

Some of the existing production and monitoring wells are currently sampled through other monitoring programs. The locations of wells included in this recommended monitoring program are shown in Figure 11-8.

The monitoring program recommended for Alternative 1 could require modification as additional data are gathered or as conditions change. Events that could lead to modification of the monitoring program include:

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- Abandonment (by the well owner) of existing wells currently planned for inclusion in the program, which may require the installation and/or sampling of additional wells to fill data gaps caused by the abandoned well(s)

- Detection of deviations from the estimated influent concentrations, which may require installing additional wells to evaluate the magnitude and cause of the observed deviation(s)

- Site investigations at individual facilities in the OU area that may identify desirable locations for additional monitoring wells or result in the installation of new wells that should be included in the monitoring program

Reasonable deviations to conceptual level contingency plans.

11.3.2 Alternative 1 Extraction

The specific extraction rates and locations required to meet the remedial objectives of the OU in each of the contamination subareas are described in Section 7 (Alternative 1 focuses on Subareas 1 and 3 only). The Alternative 1 extraction system is configured to continuously extract 19,000 gpm from the aquifer at five locations in the OU area. Recommended extraction well locations are shown in Figure 11-7. The extraction well clusters have been located at sites with historical water quality data (adjacent to existing production or monitoring wells), if possible. Clusters 5 and 13 are located at sites with no historical water quality data. Data from the monitoring program described above and in more detail in Appendix E would be used to verify or modify the recommended well locations during remedial design.

Final details are left to the design phase.

As described in Section 7, the aquifer in the OU area is very productive. Data indicate that between 5,000 and 22,000 gpm of water could be extracted from a single well or well cluster with a drawdown of 50 feet. These data were used, along with the modeling described in Section 7, to select extraction rates for each of the recommended clusters. Because the available extraction capacity of existing wells is limited (see Section 7.1), a combination of new and existing wells is recommended. Table 11-4 contains construction details and recommended flow rates for the extraction wells, both new (five) and existing (two). Of the five recommended well clusters, three contain only new wells and two have both existing and new wells. As described in Section 7, this OU is focused on the upper 400 to 500 feet of the aquifer only. The extraction well construction details provided in Table 11-4 reflect the current understanding of the vertical extent and distribution of VOC contamination in the OU area (described in Section 3 and illustrated in Figure 3-9).

Alternatives are based on probable conditions in the conceptual model.

The water produced in this alternative would be supplied to local purveyors. Because these purveyors could use their existing supply system as a backup supply, it is not deemed necessary to assume emergency backup extraction capacity for Alternative 1.

Assumptions.

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11.3.3 Alternative 1 Treatment

Alternative 1 treatment is configured to treat 19,000 gpm of groundwater to primary drinking water standard MCLs at four treatment plants (Treatment Plants 4, 5, 6, and 10). The treated water would be piped to water purveyors for local use. The following subsection describes the treatment process equipment. Tables 11-5, 11-6, 11-7, and 11-8 for Treatment Plants 4, 5, 6, and 10, respectively, summarize estimates of average and peak concentrations in the blended influent for 18 VOCs, NO_3, and Rn. [Note: Tables 11-5, 11-6, 11-7, and 11-8 not included in this example.] The tables also list the percentage reduction required to reduce the estimated peak and average concentrations to the treatment objectives. Section 7.3 describes the methodology used to estimate contaminant concentrations at the five well clusters. Section 8.1 identifies assumptions made in identifying treatment objectives.

Assumptions and objectives.

11.3.3.1 Treatment Process

The treatment process assumed for Alternative 1 consists of air stripping with VGAC adsorption for air emission control. Air stripping transfers VOCs from groundwater to air, and VGAC adsorption transfers VOCs from the air stripper off-gas to an adsorbent. Section 8.2.3 details the treatment process configuration. A process flow diagram for the Alternative 1 treatment plants (which is valid for all treatment plants included in the four remedial alternatives) is shown in Figure 11-9. The facilities would require about 1 acre of land for Treatment Plants 4, 5, and 6 and about 3 acres for Treatment Plant 10. An equipment list for each plant is provided in Tables 11-9, 11-10, 11-11, and 11-12 for Treatment Plants 4, 5, 6, and 10, respectively. [Note: Tables 11-10, 11-11, and 11-12 not included in this example.]

Air Strippers. A total of eight air strippers would be required at the four plants to accommodate the 19,000-gpm flow rate. The assumed flow rate through each stripper ranges from 2,000 to 2,833 gpm. Each stripper would be 10 to 12 feet in diameter, with two 20-foot packed beds per stripper, for an overall height of approximately 65 feet. Air-to-water ratios would range from between 30 and 57:1 for estimated average influent concentrations and between 50 and 75:1 for estimated peak influent concentrations, respectively. The strippers are assumed to be constructed of fiberglass-reinforced plastic with stainless steel internals (i.e., internal redistributor and demister) and plastic packing. Each stripper would also include the following ancillary equipment: a basket/filter strainer, flow controller and modulating valve, blower, internal redistributor, and demister packing. The most difficult VOC to remove by air stripping is 1,2-DCA. As configured, the strippers at the various plants would remove between 75 and 96 percent, at a minimum, of the 1,2-DCA at average influent concentrations and between 90 and 98 percent, at a minimum, of the 1,2-DCA at peak influent concentrations.

Details of the preconceptual design are assumed for the detailed evaluation.

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VGAC Adsorbers. Each air stripper would require between two and four parallel VGAC adsorbers to treat the air stripper off-gas. Thus, 8 sets of 2 to 4 adsorbers each are assumed for the Alternative 1 treatment plants (23 adsorbers total). The assumed size of the adsorbers is 12 feet in diameter with a 3-foot bed depth and an overall height of 10 feet; each would contain 10,000 pounds of Calgon BPL or equivalent carbon. Superficial air velocities would range from 0.82 to 0.99 feet per second (fps) for average concentrations and from 0.90 to 1.08 fps under peak influent concentrations. Each adsorber is assumed to be constructed of carbon steel and include the following ancillary equipment: an off-gas heater, an off-gas blower, and a flue stack. One 20-foot-diameter spent carbon storage silo and one 20-foot-diameter fresh carbon storage silo would also be provided at each treatment plant. As described in Section 8.5, it is not anticipated that significant construction modifications would be required to address Rn. Each adsorber would be designed to remove at least 90 percent of the VOC mass emitted by the air stripper air emissions.

Assumptions.

Design details are worked out to whatever level is required to estimate cost and to ensure that the alternative is feasible and effective. Critical details often must be very specific.

Effluent Discharge Basin. An effluent discharge basin would be included at each treatment plant that provides 1-hour residence time for the treated groundwater. The basins are assumed to be constructed of reinforced concrete and have capacities of 150,000 to 520,000 gallons. Ancillary equipment would include a dry well and effluent discharge pumps.

Effluent Chlorinator. A single effluent chlorinator, using gaseous chlorine, is assumed at each treatment facility. The effluent discharge basin would be used as the contact chamber.

Corrosion Control. Facilities are assumed to be needed for pH adjustment to provide corrosion control (i.e., reduce lead and copper levels) at each treatment plant. The actual need for disinfection and corrosion control would be determined during remedial design.

Some details can be left to the design phase when they do not affect feasibility, effectiveness, or cost.

11.3.4 Alternative 1 Conveyance

The conveyance system assumed for Alternative 1 would convey water from the extraction wells to the treatment plants (all of which are located at the wellhead of extraction clusters), and from the treatment plants to the selected water purveyors. The actual locations of pipelines and other conveyance hardware are likely to differ from those assumed, depending on the final locations of the extraction wells, treatment facilities, and distribution points. A summary of the recommended conveyance facilities is provided below. A detailed description of the facilities, the criteria used to develop the system, and the method of evaluation can be found in Appendix F.

Actual design will differ, but the alternative must assume some specificity in order to estimate cost for evaluation.

11.3.4.1 Pipelines

The pipelines, shown in Figure 11-7, consist of approximately 37,400 linear feet of pipelines ranging from 10 to 24 inches in diameter. The assumed alignments have been selected to reduce construction costs and minimize

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environmental impacts. The alignment selection process included a survey of underground utilities and a field investigation to evaluate potential construction difficulties. Pipes are located in larger streets to minimize traffic disruption and maintain access to local businesses and residences.

Some details must be explained carefully because of their large impact on total cost.

11.3.4.2 Pumps

The pumping component of Alternative 1 is divided into two categories: well pumps and pump station. All well pumps are assumed to be single-speed pumps to minimize cost. Seven well pumps are recommended to convey contaminated groundwater from the extraction wells to the treatment facilities, with flow rates ranging from 1,500 to 4,000 gpm. The flow rates and associated pump horsepower (hp) are presented in the Summary of Extraction Wells table in Figure 11-7. Pump size is based on the assumption that the minimum water table elevation in the Baldwin Park key well is 200 feet. The Alhambra Judgment directs the Watermaster to recharge the aquifer to the extent practical to maintain the water level above this elevation.

Five pumping stations are assumed: a pump station located at each of the four treatment plants and a booster pump on Distribution Point G. The treatment plant pump stations are configured to deliver water to the purveyors; each has one to two pumps ranging in size from 150 to 400 hp. To provide water to the SGVWC at Distribution Point H, a small booster pump (50 hp) is assumed at Distribution Point G.

There is a potential that SGVWC would need additional storage facilities to accept the recommended constant flow of OU water at Distribution Points F, G, and H. However, no reservoirs at this time have been included in the conveyance system cost estimates. Seventeen MG of storage capacity currently exists at the three SGVWC tie-in locations in question (Distribution Points F, G, and H).

Electrical facilities required for the well pumps and pump stations would include reduced voltage starters at each pump (to minimize disturbance to the local power system) and a transformer at each well cluster and pump station.

11.3.4.3 Power Requirements

Alternative 1 power requirements consist of power for the extraction wells, pump stations, and treatment plant. The extraction wells require about 1,590 kilowatts to operate on a continuous basis. The pump stations require about 780 kilowatts and the treatment plants require an additional 450 kilowatts. Thus, the total Alternative 1 power requirements are approximately 2,820 kilowatts. However, the net power requirements would be less because purveyors receiving OU water would reduce production at existing wells to offset much of the new production. It is assumed that

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approximately 14,000 of the 19,000 gpm delivered to the purveyors would replace existing groundwater extraction. A rough estimate of the average power consumption by the water purveyors for this existing extraction is 730 kilowatts. The net power requirements for Alternative 1 would thus be 2,820 - 730 = 2,090 kilowatts.

Where reasonable, estimates can be used in place of hard data.

11.3.5 Alternative 1 Water Use

Thirteen purveyors with existing conveyance facilities in the OU vicinity have been identified as potential recipients of water from an OU treatment plant (see Section 9.2). It is assumed that water supplied to purveyors would supplant a portion of the purveyors' existing supply. It is assumed that the volume of water supplied would be deducted from the purveyors' production right, such that purveyors would still be required to provide replacement water if total water use (OU and otherwise) exceeds their production right.

Institutional issues.

As outlined in Section 9.2, it is assumed that treated water would be supplied to purveyors at constant flow and pressure. Discussions have been held with most of the purveyors that either extract water or distribute water in the OU vicinity to gather data on potential flow rates and distribution locations for accepting water from an OU treatment plant. Table 9-4 provides information on the potential distribution locations identified in the OU area for redistribution to local purveyors. Figure 11-7 shows the distribution locations and associated flow rates included in this alternative. In developing this subset of the larger list of distribution points, emphasis has been placed on providing water to purveyors with distribution facilities in the vicinity of the recommended extraction well locations to minimize pipeline costs. Alternate distribution options were evaluated as part of the alternative development options described in Section 11.1.1.

(Note: The remainder of Section 11.3 and all of Sections 11.4 through 11.6 are not included in this example.)

11.7 Recommended Components of the Remedial Alternatives Incorporated Because of the Uncertainty in Future Contaminant Concentrations

Sections 11.3 through 11.6 describe many of the assumptions made in estimating the size and configuration of the remedial alternatives. One set of critical assumptions is the future concentrations of selected VOCs (especially TCE, 1,2-DCA, 1,1-DCE, and vinyl chloride), NO_3, and other water quality parameters. Section 7.3 provides estimates of future concentrations and describes the magnitude and duration of possible deviations from the estimates. This section describes components of the remedial alternatives incorporated to respond to possible deviations from estimated concentrations.

Assumptions and modeling results. The importance of the conceptual model is clear at this point.

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11.7.1 Excess Space at the Assumed Treatment Facility Parcel to Allow for Future Facility Expansion

Section 7.3 describes the difficulty in predicting future contaminant concentrations, which a treatment facility must be designed to handle. If concentrations of VOCs, NO_3, or other water quality parameters increase substantially, additional land may be required for expansion of the VOC treatment facility, for installation of NO_3 treatment, or installation of other treatment hardware. If land is acquired only for initially planned facilities, it may subsequently prove unfeasible to acquire adjacent parcels needed for treatment facility expansion.

Some uncertainties can be left to contingency plans. Others have to be allowed for (at least in critical details) as part of the base alternatives.

11.7.2 Safety Factors Included in Estimating the Size and Configuration of the Treatment Facility

The safety factors incorporated into the treatment facility configurations for all alternatives include:

- **Air Strippers**
  - Ten percent excess air stripper blower capacity
  - Twenty-five percent excess air stripper packed bed depth
  - A:W rounded up to the nearest increment of five
  - Conservative liquid loading rates of 25 gpm/ft^2
- **VGAC**
  - Minimum spare capacity of about 20 percent
  - Use of conservative isotherm values
  - Usage safety factor of 100 percent
  - Space at treatment facility for additional VGAC adsorbers

Normal engineering safety factors in the assumed pre-conceptual design are not considered to be contingency plans (although they do result from uncertainties) because they would be implemented as part of the base alternative.

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Table 11-4
Extraction Well Information
(19,000 gpm Extraction)

Cluster No.	Existing Well No.	Well Name	Well Owner	Well Depth (ft)	Perforated Interval (ft)[1]	Operating Capacity (gpm)[2]	No. of New Wells	New Well Depth (ft)	New Well Perforated Interval (ft)	New Well Capacity (gpm)	Total Pumping Rate (gpm)
4	01900035	Big Dalton	VCWD	600	254-587	2,500[3]	0	-	-	-	2,500
5	-				-			600	50-580	4,000	4,000
6	01900031	Paddy Ln.	VCWD	600	300-585	2,500[4]	1	700	160-680	1,500	4,000
0							2	600	290 580	5,500	5,500
13			-				1	600	290 580	3,000	3,000
Total Rate (gpm)		-	-	-	-	5,000	-	-	-	14,000	19,000

[1]Some wells have multiple perforated intervals. Values shown represent top of uppermost, and bottom of lowermost, perforated interval.
[2]If retrofitted with new equipment.
[3]Actual potential capacity is 3,700 gpm. Well would be retrofitted to a capacity of 2,500 gpm.
[4]Actual potential capacity is 2,900 gpm. Well would be retrofitted to a capacity of 2,500 gpm.

While any of the details may change in the design phase, the alternatives, especially the cost estimates, have to be reasonably specific in order to support the detailed evaluation.

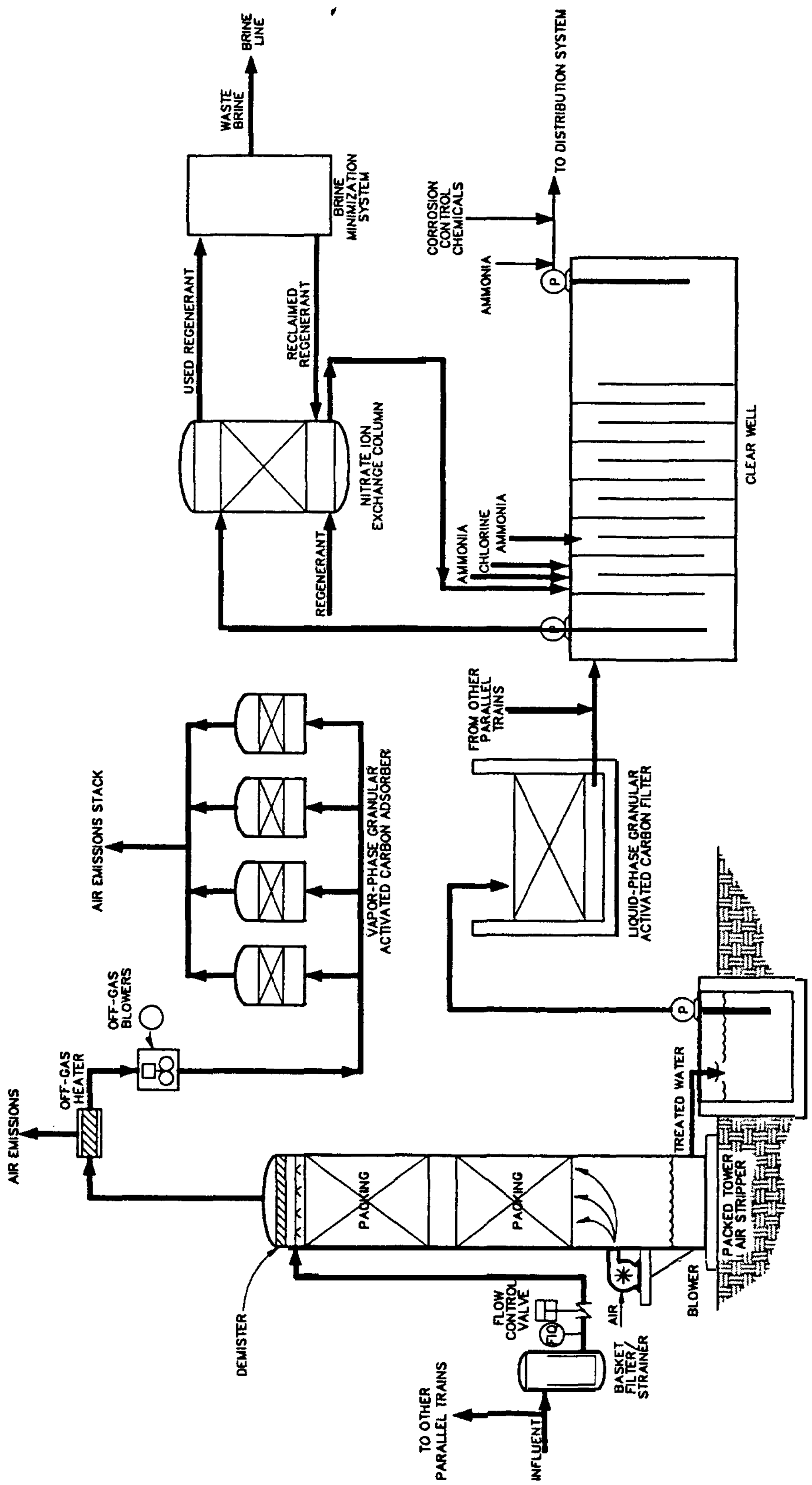

FIGURE 1
TYPICAL TREATMENT PLANT
PROCESS FLOW DIAGRAM

Note B. **Example Evaluation of Deviations and Contingency Plans for Detailed Analysis.** Alternatives definition includes identification of contingency plans for each of the identified reasonable deviations. The contingency plans must be developed sufficiently to evaluate three criteria: **implementability**–the ability to assume that a contingency plan can be implemented and relied upon to work effectively; **protectiveness**–the ability of the contingency plan to provide equal or greater protectiveness and achieve ARARs as effectively as the base alternative; and **cost**–the approximate cost of implementing the contingency.

This example is from the Baldwin Park OU FS. Baldwin Park is part of the EPA's San Gabriel Basin NPL site in Los Angeles County. The no-action alternative and Alternative 1 for Baldwin Park are described in detail in Submodule 5.1, Note A. This note focuses on deviations and contingency plans for the treatment component of the alternatives. Figure 1 is a conceptual illustration of the treatment system.

This excerpt from the FS describes the impacts the reasonable deviations would be expected to have on the treatment system, and the contingency plans for managing each deviation. Table 1, which does not appear in the FS, provides a summary of the probable conditions, design capacity, deviations, and contingency plans for contaminants and other operating parameters. See Submodule 5.1, Note A, for additional details on the alternatives, including monitoring systems. Note that the contingency plans are not developed in detail in the FS. It is only necessary to ensure that a contingency plan is available in concept and that its implementability, effectiveness, and cost can be evaluated. Contingency plans are later worked out in detail during the remedial design phase.

Evaluation of the impacts of deviations and the development of appropriate contingency plans are highly site-specific. This example should not be extended beyond its use as an illustration of contingency plan development during an FS.

This is an unedited version of the deviations and contingency plans discussions as it appeared in the Baldwin Park work plan. This excerpt is from *Conjunctive Use Feasibility Study, San Gabriel Basin, Los Angeles County, California* (CH2M HILL, 1993). Use of the excerpt is illustrative and does not necessarily represent any activity currently under way.

Table 1
Contingency Plan Matrix for Treatment

Contaminant	Probable Condition	Design Capacity	Deviation	Contingency Plans
Organics				
1,2-Dichloroethane	**10 ppb**	**12 ppb**	> design	- Modify extraction - Increase air-water ratio - Increase LGAC carbon usage if air stripper capacity exceeded
1,1-Dichloroethene	63 **ppb**	63 **ppb**	> design	- Increase rate of carbon usage in VGAC **(1,1-DCE,** TCE)
Trichloroethylene	591 ppb	638 ppb	> design	- Increase rate of carbon usage in VGAC **(1,1-DCE,** TCE)
Radon	350 **pCi/l**	1,500 **pCi/l**	N/A	N/A
Nitrate	37 **ppm**	**45 ppm**	> design	- Increase ion exchange regulation
			< treatment objective = 36 ppm	- Discontinue ion exchange
Iron	< MCL = 3 ppm	< 3 **ppm**	> 3 **ppm**	- Add oxidation and filtration components to treatment train
Flow Rate/Stripper	**2,900 gpm**	**2,900 gpm**	> design	- Bring offline stripper online
			< design	- Remove strippers from service
Water Temperature	64°F	64°F	< 64°F	- Decrease air-water ratio - Reduce VGAC usage
			> 64°F	- Increase air-water ratio - Increase VGAC usage
Other Contaminants	No new Contaminants of Concern	Contaminants of Concern	Heavy metals, non-strippable **organics** (e.g., pesticides)	- Add new components to treatment train

4.5 Potential Responses to Influent Deviations

Uncertainties.

Uncertainty in the assumed characteristics of the influent water results in part from uncertainty in the precise distribution and magnitude of groundwater contamination, and is compounded by the fact that groundwater extraction will alter flow patterns and remove dissolved contaminants from the groundwater system. Thus, it is reasonable to expect deviations may increase with time. Therefore, it is important to describe the potential nature of deviations and to assess their impact and evaluate potential responses (the sensitivity of the treatment process to changes in contaminant concentrations is described in Subsection 4.6.1). Types of deviations may include:

Reasonable deviations.

- Increases or decreases in influent concentrations
- Increases or decreases in wellhead flow rates
- Increases or decreases in influent temperature
- Discovery of new contaminants

Potential impacts of and resulting responses to these deviations are discussed below. The potential deviation scenario is based on the 100-mgd treatment plant described above.

4.5.1 Increases or Decreases in Influent Concentrations

Potential deviations in influent concentrations are listed in Table 4-19. The basis for these estimates of potential deviations is explained in Section 5. As shown in Table 4-19, potential deviations in four contaminants could impact treatment system operation or design. The four contaminants are 1,2-DCA; 1,1-DCE; TCE; and nitrate.

Probable conditions.

As outlined in Section 5, a probable set of influent conditions has been estimated based on observed historical data and interpretations of hydrogeologic conditions. The probable estimates have been subdivided into "average" and "peak" concentrations. Peak concentrations represent likely peaks in individual contaminants that are considered likely to occur on a somewhat frequent basis. Thus, treatment facilities must be capable of treating these concentrations. Average concentrations represent the mean of fluctuations in influent concentrations and are used as a basis for O&M cost estimates (in particular, carbon usage). Although deviations in conditions could result in either increases or decreases in concentrations, only potential increases will be considered. Deviations that are greater than the probable peak or average concentrations, and are considered less likely, but still possible, within the lifetime of the facility.

Table 4-19
Estimated Deviation Concentrations

Contaminant	**Estimated Concentration (μg/l)**		
Controlling VOCs[1]	**Probable Peak**	**Treatment Plant Capacity**[2]	**Potential Deviation**[3]
Trichloroethylene (TCE)	591	638	**889**
1,1-Dichloroethane (1,1-/DCA)	13	169	32
1,1-Dichloroethene (1,1-DCE)	63	63	**119**
cis-1,2-Dichloroethene (C-1,2-DCE)	39	115	37
trans-1,2-Dichloroethene (T-1,2-DCE)	15	115	37
1,2-Dichloroethane (1,2-DCA)	10	12	**19**
Acetone	39	237	72
Methylene Chloride	0.7	7.3	1.8
Vinyl Chloride	1.2	--[4]	3.2
Trichlorofluoromethane (TCFM)	1.5	56	3.5
Other VOCs			
Tetrachloroethene (PCE)	152	825	318
Carbon Tetrachloride (CTC)	8.5	654	12
1,1,1-Trichloroethane (1,1,1-TCA)	88	646	216
Benzene	0.6	324	1.2
Toluene	0.3	739	0.5
Bromodichloromethane (BDCM)	2.3	1,231	6.9
Chloroform	9.6	174	12.4
Chlorobenzene	0.7	597	1.9

Table 4-19
Estimated Deviation Concentrations

Contaminant	Estimated Concentration (μg/l)		
Controlling VOCs[1]	**Probable Peak**	**Treatment Plant Capacity[2]**	**Potential Deviation[3]**
Inorganic Contaminants			
Nitrate (as NO)	37 mg/1	45 mg/1	**100 mg/1**
Radon	350 pCi/1	1,500 pCi/1	**--**[5]

Notes:
[1]Compounds that may control cost or limit selection of various treatment methods.
[2]The concentrations in this column are the maximum concentrations of the contaminants that the proposed treatment plant can handle without impacting plant operations and design.
[3]The concentrations in this column are estimated concentrations that could occur in the Baldwin Park area groundwater. These concentrations are considered less likely than the probable peak, but still possible within the lifetime of the facility. Numbers shown in bold-face font indicate contaminant concentrations that would impact plant operations and design.
[4]It has been assumed that vinyl chloride would be allowed to pass through the off-gas vapor phase carbon treatment system. Therefore, the limiting concentration would more likely be based on air-rick analysis rather than water treatment objectives.
[5]Limited radon data are available for Baldwin Park area groundwater; therefore, potential deviations based on available data are not provided at this time.

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4.5.1.1 Organics An increase in influent VOC concentrations may cause an increase in carbon usage and therefore increase O&M costs and labor time required to change-out spent carbon. An increase in organic concentrations may also require a change in air stripper operating conditions to meet treatment objectives. The deviation influent concentration of 1,2-DCA (see Table 4-19) exceeds the air stripper treatment capacity. If this should occur, the redundant LGAC absorber would act as a polisher and effectively treat the 1,2-DCA to its treatment objective; no additional changes in air stripper operation would be required. However, if the LGAC adsorber is required to remain solely as a redundant system then either increasing the air-to-water ratio or modifying extraction would be required. An additional parallel VGAC adsorber may have to be installed for each air stripper if the contaminant concentrations significantly increase.	**Contingency plan.**
4.5.1.2 Increase in VGAC Use An increase in influent concentrations will increase the rate of VGAC carbon usage. Two of the contaminants with potential deviation concentrations listed in Table 4-19 that exceed the treatment plant capacity, 1,1-DCE and TCE, would use up more VGAC if the influent concentrations do exceed the treatment plant capacity values listed.	**Deviations that only increase costs in a small way may not require contingency plans.**
4.5.1.3 Increase in LGAC USE In general, an increase in the influent concentrations for the VOC contaminants will not impact system design significantly because the LGAC adsorbers provide redundant treatment. Increased influent concentrations would cause an increase in AGAC usage only if the air stripping capacity were exceeded. **4.5.1.4 Radon** Impacts of radon (Rn) concentrations are discussed in Section 4.6.2. A quantitative estimate of treatment plant capacity for Rn removal has been performed based on the 100-mgd treatment plant and an estimation method developed by CH2M HILL (Martines, 1991). The ultimate disposal classification for spent carbon (210-Pb and Radium [Ra]<3.0 pCi/gm) remains unchanged between the peak concentration of 350 pCi/1 and the deviation concentration of 1,500 pCi/1. However, if Rn activity is required to be limited, additional onsite storage of spent VGAC may be required.	

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Assuming a conservative 0.1 mRem/hr acceptable operator exposure threshold (equal to 1 hour/day maximum allowed exposure time), the radon concentration in blended influent groundwater could increase to approximately 1,500 pCi/1 before requiring the addition of vessel shielding, based on maintaining a stripper air-to-water ratio greater than 50:1.	**Contingency plan.**
4.5.1.5 Iron	
If the treatment plant influent iron concentration were to increase to 0.3 parts per million (ppm), a secondary drinking water MCL, then additional treatment may be required. Treatment would include oxidation of the ferrous ion (+2 valence) to ferric iron (+3 valence) followed by filtration. Oxidation techniques include forced draft aeration, prechlorination, potassium permanganate pretreatment, and oxidation/filtration using manganese green sand.	**Contingency plan.**
4.5.1.6 Nitrate	
If the influent of the Baldwin Park groundwater were to increase above the treatment plant capacity concentration shown in Table 4-19, more frequent ion-exchange (IE) regeneration would be required or more IE capacity would need to be constructed. If the influent concentration of nitrate decreases to below the treatment objective, the IE treatment of nitrate may be discontinued or the nitrate treatment objective may be met by blending with other low nitrate streams.	
4.5.2 Increases or Decreases in Influent Flow Rates	
If the flow rate to the treatment facility increases or decreases, offline stripping towers will be brought online or removed from service, respectively.	**Contingency plan.**
4.5.3 Increases or Decreases in Influent Temperature	
It is unlikely temperatures will deviate enough to impact treatment facility operations. However, if the temperature of the influent water were to increase, the air-to-water ratio could be decreased and VGAC usage may be reduced. Conversely, if the influent water temperature were to decrease, the air-to-water ratio would have to be increased and VGAC usage may increase.	**Contingency plan.**
4.5.4 New Contaminants	
Groundwater monitoring results for contaminants of concern are available for a wide radius from the proposed extraction wells. Although the contaminants of concern have been identified and included in treatment process selection, identification of a new contaminant(s) could change the required treatment of Baldwin Park area groundwater. Examples of contaminants that could require selection of new treatment processes are heavy metals and nonstrippable organics such as pesticides.	**A deviation considered so unlikely that a contingency plan is not appropriate in the FS.**

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Note C. **Example Reasonable Deviations and Contingency Plans.**

The following are reasonable deviations and associated contingency plans for the developed alternative presented in Submodule 5.1, Note A.

Probable Condition: The calculated volume for excavation and the conceptual excavation plan are based on the apparent condition that the limit of the infiltration of the PCBs is well defined, averages 11 feet, and is in no area greater than 21 feet.

Reasonable Deviation: A lens of higher permeability soils, such as has been encountered in other parts of the site, exists within the excavation area and has allowed downward migration beyond 11 feet, perhaps as far as the aquitard, which is generally encountered at a depth of 35 feet in the area of planned excavation. Increases in the total costs for excavation, transportation, and incineration could be increased by as much as 70 to 100 percent, given a plausible size lens of higher permeability material and assuming the contamination does not extend all the way to the aquitard in even the deepest area.

Contingency Plan: The soil type and level of contamination in the soils will be monitored during excavation. If higher permeability soils or deeper levels of contamination are discovered, the levels of contamination at the lower depths will be presented to the regulators to determine the need for excavation. If excavation is required, a modified excavation plan will be prepared for review by the project engineer, DOE, and the regulators. The incineration services subcontractor and the state where the incinerator is located will be informed of the additional volume of soil to be treated. The additional costs and services will be handled as change orders under the provisions of the contracts.

Probable Condition: The conceptual remedial measure assumes that suitable borrow can be obtained for the base material, which will be used to establish a consistent grade under the cap, from one of the two identified potential borrow areas. The two areas are both within 5,000 yards from the landfill and adjacent to one of the two roads in the area.

Reasonable Deviation: The two areas where fill was assumed to be available are contaminated with superficial radiation high enough to preclude use as fill material.

Contingency Plan: The next best area for obtaining borrow is the undisturbed area on the plateau, which is nearly 8,000 yards from the landfill and not accessible by existing roads. This area almost certainly is not contaminated. A temporary road will be constructed to the area, avoiding the Native American site identified during the historical artifacts survey. If necessary to implement this contingency plan, the $1.4 million estimated for base material would increase to approximately $2.5 million.

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Probable Condition: Groundwater containing dissolved chromium (Cr^{+6}) in excess of MCLs has been delineated in a shallow aquifer zone. The upper aquifer is separated from a deep drinking water aquifer by a clay aquitard. The permeability of the aquitard has been measured at 10^{-8} cm/sec and is assumed to restrict movement of contaminated groundwater downward to deeper zones. No drinking water wells exist in the area of shallow groundwater contamination. A deep investigation was not conducted because of the potential for contaminating the deep zone during drilling. The remedial action addresses removal and treatment of shallow groundwater using conventional pump and treat technologies.

Reasonable Deviation: Chromium contamination will be identified in the deep drinking water aquifer downgradient of the shallow chromium plume. Potential migration pathways from the shallow to the deep aquifer are along improperly abandoned wells and permeable discontinuities in the aquitard. Neither of these pathways was identified during the shallow groundwater investigation.

Contingency Plan: The cost of this deviation is very significant and raises the overall cost by 200 to 300 percent. This level of impact on cost may be sufficiently significant to create a fundamental change of scope in the ROD (see Submodule 6.3, Post-ROD Changes). As such, this deviation might be deemed unreasonable and therefore more information may be needed to reduce this uncertainty. However, if the extended project team agrees that the uncertainty resulting in this cost variation can be managed as a reasonable deviation, the contingency plan could consist of the following actions:

- Groundwater users in the area will require an alternate water supply. The local utility will connect residences in the area to the public water supply at an approximate cost of $10,000 per connection. This action will protect the public from future potential exposures and mitigate spreading of the deep contamination by pumping at residential wells.

- An intensive investigation will be conducted to locate abandoned wells. Each well will be assessed to determine whether it acted as a conduit for downward movement of chromium-tainted groundwater. Each well must also be properly abandoned.

- A focused RI of the deep aquifer will be required to determine the extent of contamination and to collect information for developing remedial actions for the deep aquifer. This investigation requires a high level of field quality assurance/quality control (QA/QC) procedures to distinguish between the shallow and deep contamination.

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- The need for and effectiveness of a remedial action for the deeper zone will be evaluated. A pumping system probably will be required. The existing treatment plant built for the shallow aquifer contamination will be expanded to accommodate water produced from the deeper zone.

Submodule 5.2 Alternatives Analysis

Detailed Analysis of Alternatives

5.1 Alternatives Definition

5.2 Alternatives Analysis

5.3 Feasibility Study Report

5.2 Alternatives Analysis

- Individual Analysis of Alternatives
- Comparative Analysis of Alternatives

Submodule 5.2 Alternatives Analysis

Background

The evaluations conducted during the detailed analysis phase build on previous evaluations conducted during the development and screening of alternatives (Module 4). Technology effectiveness, implementability, and cost are evaluated during the detailed analysis to develop the rationale for a remedy selection. The analytical process described here has been developed on the basis of statutory requirements of CERCLA Section 121 and the NCP [300.430(e)(9)].

Organization

Submodule 5.2 discusses the following:

- Individual Analysis of Alternatives
- Comparative Analysis of Alternatives

In addition, more detailed information is provided in the following notes:

- Note A–Evaluation Criteria
- Note B–Example Summary of Individual Analysis of Alternatives
- Note C–ARARs Waivers
- Note D–Example Summary of Comparative Analysis of Alternatives

Sources

1. Montana Department of Health and Environmental Services, October 1989, *Silver Bow Creek Investigation, Feasibility Study for the Warm Springs Ponds Operable Unit*, Volume I-Report.

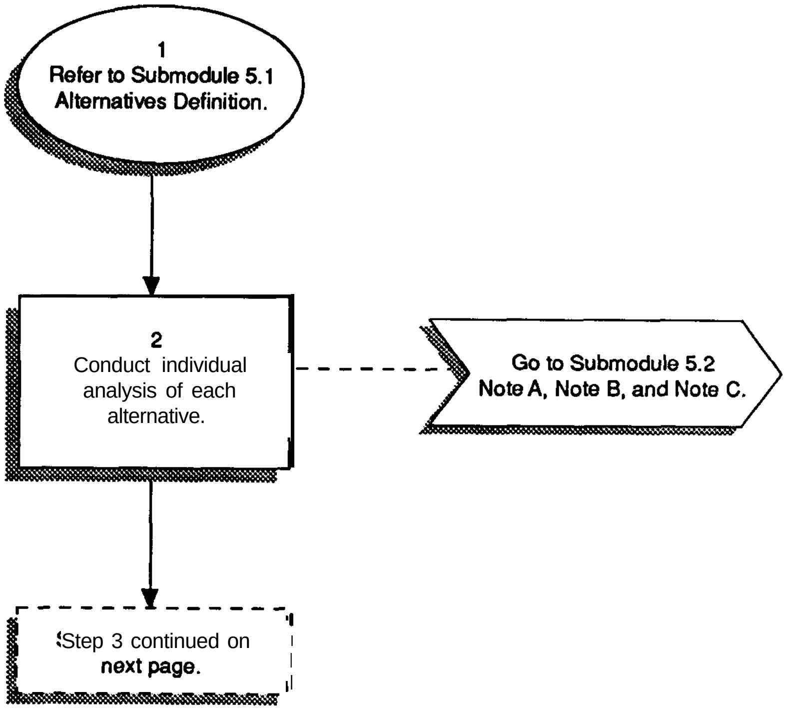
2. U.S. EPA, December 1987, *Remedial Action Costing Procedures Manual*, EPA/600/8-87/049, OSWER Directive 9355.0-10.

3. U.S. EPA, October 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, Interim Final, EPA/540/G89/004, OSWER Directive 9356.3-01.

4. U.S. EPA, August 1989, *CERCLA Compliance With Other Laws Manual*, EPA/540/G-89/009, OSWER Directive 9234.1-2.

5. U.S. EPA, December 1991, *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, (Part C, Risk Evaluation of Remedial Alternatives)*, OSWER Directive 9285.7-01C.

Submodule 5.2 Alternatives Analysis



NOTE:
Alternatives analysis is conducted using seven of the "nine criteria":

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness andpermanence
- Reduction of toxicity, mobility, or volume through treatment
- [illegible]
- Implementability
- cost

Step 1. Refer to Submodule 5.1, Alternatives Definition.

Step 2. **Conduct individual analysis of each alternative**. The individual analysis consists of developing an assessment and a summary profile of each alternative on the basis of seven of the nine evaluation criteria specified in the NCP [300.430(e)(9)(iii)]. The seven criteria are as follows:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

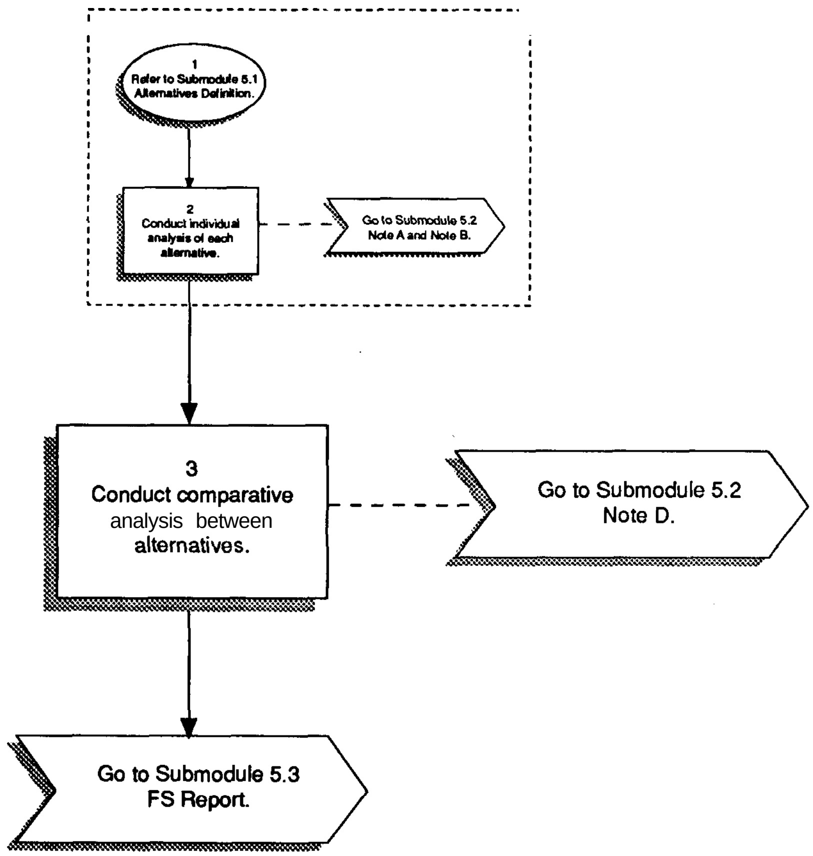
The first two criteria are threshold criteria; that is, any alternative to be considered in the final evaluation must meet these threshold criteria. Analysis of the threshold criteria is straightforward. Overall protection of human health and the environment consists of simply describing how pathways of exposure are addressed. Compliance with ARARs is a determination of whether the alternative meets ARARs or if a waiver is appropriate for ARARs not met. Submodule 5.2, Note C, discusses ARARs waivers. Submodule 6.2, Note B, provides example waiver language. The next five criteria are considered balancing criteria in the FS. The majority of the analysis is evaluation of the balancing criteria. Potential tradeoffs between the alternatives are identified during the evaluation and presented to the decisionmaker. The evaluation of the last two criteria (modifying criteria)−state and community acceptance−is formally conducted as part of the ROD, after the alternatives have been presented to the public. Module 6, Remedy Selection and Documentation, presents the remedy selection framework.

The level of detail required in the analysis depends on the type and complexity of the site, the type of process options and alternatives under consideration, and other project-specific considerations. The analysis should be conducted in sufficient detail so that decisionmakers understand the significant aspects of each alternative and any uncertainties associated with the evaluation (e.g., a cost estimate developed on the basis of an uncertain volume of media). Submodule 5.2, Note A, describes the first seven of the nine evaluation criteria and their use in the evaluation process. Submodule 5.2, Note B, is an example of an individual analysis summary.

The detailed analysis considers both the alternatives and the contingency plans. Each alternative must be completely analyzed against the first seven criteria. However, the contingency plans are evaluated differently.

A contingency plan, considered together with its cost and other impacts, is a factor when evaluating an alternative. Each alternative may have multiple contingency plans. If a contingency plan cannot be developed to respond to a reasonable deviation, the alternative may not be a good candidate for remedy selection. This problem might have been identified during alternatives screening (Submodule 4.4), but only confirmed through definition of the alternative. The identification of a feasible contingency plan for each reasonable deviation should be a basic requirement for all alternatives considered in the detailed evaluation.

Submodule 5.2 Alternatives Analysis (cont.)



The three considerations for evaluating each contingency plan are presented in Step 3 of Module 5.1; they address feasibility, protectiveness, and cost. If a contingency plan can be implemented and relied on to work effectively, if it will provide protectiveness and ARARs compliance equal to the alternative, and if its costs can be considered acceptable, its associated alternative can be considered for selection despite the reasonable deviation addressed by the contingency plan. In making this assessment of a contingency plan during the evaluation of the alternative, the seven technical criteria are applied as appropriate, emphasizing those affected by the reasonable deviation.

The EPA *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* and the EPA *CERCLA Compliance With Other Laws Manual* provide additional information on the individual analysis of alternatives, ARARs compliance evaluations, and proper format for presenting the results of the individual analysis of alternatives in the FS report.

Step 3. **Conduct comparative analysis between alternatives**. Once the alternatives have been described and individually assessed against seven of the nine criteria, a comparative analysis is conducted to evaluate the relative performance of each alternative in relation to each specific evaluation criterion. The purpose of the comparative analysis is to identify the advantages and disadvantages of each alternative for identification of the key tradeoffs that must be balanced by the decisionmaker. The comparative analysis should not repeat the individual analysis of alternatives (discussed in Step 2), but only briefly highlight the advantages and disadvantages of each to the extent necessary to make major tradeoffs among options clear to support remedy selection. An example of a comparative analysis is presented in Submodule 5.2, Note D.

The EPA *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* and the EPA *CERCLA Compliance With Other Laws Manual* provide additional information about the comparative analysis of alternatives and the proper format for presenting the results in the FS.

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Note A. **Evaluation Criteria**

- **Overall Protection of Human Health and the Environment**. This criterion assesses whether each alternative provides adequate protection of human health and the environment. Evaluation of the overall protectiveness of an alternative should focus on whether a specific alternative achieves adequate protection, and should describe how site risks posed through each pathway being addressed by the FS are eliminated, reduced, or controlled through treatment, engineering, or institutional controls. For example, statements that provide a description of how an alternative achieves protection should be noted up front. These can include phrases such as, "the remedy removes the source term," "terminates the risk pathway," or "shields the receptor from exposure." The assessment of overall protection can use the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. This evaluation also allows for consideration of whether an alternative poses any unacceptable short-term or cross-media effects.

  In addition, these criteria should address the ability of the alternatives to accommodate a reasonable deviation and/or availability of a contingency plan for use in the event of a deviation from probable conditions. Because protectiveness is a threshold criterion that must be met, the alternative must remain protective of human health and the environment, in the event of a reasonable deviation through implementation of the contingency plan.

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- **Compliance with ARARs**. This evaluation criterion is used to determine whether each alternative will meet all of the federal and state ARARs (as defined in CERCLA Section 121) that have been identified in previous stages of the RI/FS process. The detailed analysis should summarize which requirements are applicable or relevant and appropriate to an alternative and describe how the alternative meets these requirements. When an ARARs is not met, the basis for justifying one of the five waivers allowed under CERCLA should be discussed. Submodule 5.2, Note B, presents the conditions for obtaining a waiver. The following should be addressed for each alternative during the detailed analysis of ARARs:

  - Compliance with Chemical-Specific ARARs (e.g., maximum contaminant levels). This factor addresses whether the ARARs can be met and, if not, whether a waiver is appropriate.

  - Compliance with Location-Specific ARARs (e.g., preservation of historic sites). As with other ARARs-related factors, this involves a consideration of whether the ARARs can be met or whether a waiver is appropriate.

  - Compliance with Action-Specific ARARs [e.g., Resource Conservation and Recovery Act (RCRA) minimum technology standards]. This factor involves determination of whether ARARs can be met or will be waived.

  The actual determination of which requirements are applicable or relevant and appropriate is made by the lead agency (DOE) in consultation with the support agencies (EPA and the State). A summary of these ARARs and whether they will be attained by a specific alternative should be presented in an appendix to the RI/FS report. More detailed guidance for determining whether requirements are applicable or relevant and appropriate is provided in the *CERCLA Compliance with Other Laws Manual* (EPA, August 1989).

  The impact of reasonable deviations on ARARs compliance and the availability of contingency plans must be addressed in the evaluation. ARARs compliance is a threshold criterion that must be met.

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- **<u>Long-Term Effectiveness and Permanence</u>**. The evaluation of alternatives under this criterion addresses the results of a remedial action in terms of the risk remaining at the site after response objectives have been met. The primary focus of this evaluation is the extent and effectiveness of controls that may be required to manage the risk posed by treatment residuals or untreated wastes. The following components of the criterion should be addressed for each alternative:

  - Magnitude of Residual Risk. This factor assesses the residual risk remaining from untreated waste or treatment residuals at the conclusion of remedial activities (e.g., after source/soil containment and/or treatment are complete or after groundwater contamination management activities are concluded). The potential for this risk may be measured by risk numbers, if appropriate, or by the volume or concentrations of contaminants remaining. More information on the use of risk evaluations in the alternatives evaluation process is provided in RAGS, Part C. A quantitative risk assessment of the effectiveness of each alternative is not required and often is not useful for sites where containment is a significant factor of most of the alternatives.

    The characteristics of any treatment residuals should be considered to the degree that they remain hazardous and should account for their volume, toxicity, mobility, and propensity to bioaccumulate.

  - Adequacy and Reliability of Controls. This factor assesses the adequacy and suitability of controls, if any, that are used to manage treatment residuals or untreated wastes that remain at the site. It may include an assessment of containment systems and institutional controls to determine if they are sufficient to maintain exposures to human and environmental receptors within protective levels. This factor also addresses the long-term reliability of management controls for providing continued protection from residuals. It includes the assessment of the future need to replace technical components of the alternative, such as a cap, a slurry wall, or a treatment system in the event of failure, and the potential exposure pathway and the risks posed if the remedial action requires replacement.

    Reasonable deviations and their potential impacts on long-term effectiveness and permanence, along with any associated contingency plans, should be evaluated under this criterion. For example, if a stabilization technology fails to achieve the expected decrease in leachability of contaminants, the impact on long-term effectiveness should be assessed. If a reasonable deviation is that long-term effectiveness of one or more alternatives cannot reasonably be ensured and no adequate contingency plan can be devised, further

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site characterization or treatability studies are probably warranted to further reduce the uncertainty before selecting any of the affected alternatives.

The impact of reasonable deviations on long-term effectiveness and permanence and the availability of contingency plans to ensure long-term effectiveness and permanence must be addressed in the evaluation. Long-term effectiveness and permanence are balancing criteria that must be considered.

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- **Reduction of Toxicity, Mobility, or Volume Through Treatment**. This evaluation criterion addresses the statutory preference for selecting remedial actions that use treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances as their principal element. This preference is satisfied when treatment is used to reduce the principal threats at a site (see Submodule 4.3) through destruction of toxic contaminants, reduction of the total mass of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media.

  This evaluation would focus on the following specific factors for a particular remedial alternative:

  - The treatment processes the remedy will use and the materials they will treat
  - The amount of hazardous materials that will be destroyed or treated, including how the principal threat(s) will be addressed
  - The level of expected reduction in toxicity, mobility, or volume measured as a percentage of reduction (or order of magnitude)
  - Whether the treatment will be irreversible
  - The type and quantity of treatment residuals that will remain following treatment
  - Whether the alternative would satisfy the statutory preference for treatment as a principal element

  For treatment options, potential deviations are many. Examples are as follows:

  - The treatment technology fails to perform as expected.
  - The treatment residuals cannot be delisted from RCRA Subtitle C or cannot be disposed of as planned because of unforeseen contaminants or less than full success of the treatment technology.
  - The wastes have to be stored longer than expected prior to treatment.
  - Unforeseen contaminants in the wastes make use of the planned treatment technology impossible.

  The impact of reasonable deviations on the ability of each alternative to provide reduction of toxicity, mobility, and volume, and the availability of contingency plans to handle the deviations must be addressed in the evaluation. Reduction of toxicity, mobility, and/or volume of the wastes at a site are balancing criteria that must be considered.

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- **Short-Term Effectiveness**. This evaluation criterion addresses the effects of the alternative during the construction and implementation phase until remedial response objectives (e.g., a cleanup target) are met. Under this criterion, alternatives should be evaluated with regard to their effects on human health and the environment during implementation of the remedial action. The following factors should be addressed as appropriate for each alternative:

  - Protection of Workers During Remedial Actions. This factor assesses threats that may be posed to workers and the effectiveness and reliability of protective measures that would be taken. Issues such as radioactive emissions and corresponding doses may be quantified for comparison.

  - Protection of the Community During Remedial Actions. This aspect of short-term effectiveness addresses any risk that results from implementation of the proposed remedial action, such as dust from excavation, transportation of hazardous materials, or air-quality impacts from a stripping tower that may affect human health.

  - Environmental Impacts. This factor addresses the potential adverse environmental effects that may result from the construction and implementation of an alternative, and evaluates the reliability of the available mitigation measures in preventing or reducing the potential impacts.

  - Time Until Remedial Response Objectives Are Achieved. This factor includes an estimate of the time required to achieve protection for the entire site or for individual elements associated with specific site areas or threats.

  Reasonable deviations that could affect short-term effectiveness should be evaluated for each alternative. Examples of such deviations are as follows:

  - Much higher levels of contaminants than expected are discovered in one or more areas of the site (hot spots). This is a potential health and safety issue to workers as well as a potential release and treatability issue.

  - Fugitive emissions are more difficult to manage during remediation than expected.

  The impact of reasonable deviations on short-term effectiveness of the alternatives and the availability of contingency plans to handle the deviations must be addressed in the evaluation. Short-term effectiveness is a balancing criterion that must be considered.

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- **Implementability**. The implementability criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation. This criterion involves analysis of the following factors:

  - Technical Feasibility

    - Construction and Operation. Relates to the technical difficulties and unknowns associated with a technology. This factor was initially identified for specific technologies during development and screening of alternatives and is addressed again in the detailed analysis for the alternative as a whole.

    - Reliability of Technology. Focuses on the likelihood that technical problems associated with implementation will lead to schedule delays

    - Ease of Undertaking Additional Remedial Action. Includes a discussion of what, if any, future remedial actions may be undertaken and how difficult it would be to implement such actions. Robust technologies (the ability to address a variety of conditions) and technologies that do not severely limit future actions are preferred over other technologies. This factor is also particularly applicable for an FS addressing an interim action where additional operable units (OUs) may be analyzed at a later time.

    - Monitoring Considerations. Addresses the ability to monitor the effectiveness of the remedy and includes an evaluation of the risks of exposure if monitoring is insufficient to detect a system failure. This factor also considers the availability of parameters to determine the occurrence of a reasonable deviation.

  - Administrative Feasibility

    - Activities needed to coordinate with other offices, agencies, and the stakeholders (e.g., obtaining permits for offsite activities or rights-of-way for construction)

  - Availability of Services and Materials

    - Availability of adequate offsite treatment, storage capacity, and disposal services. This factor is especially relevant for sites containing mixed (hazardous and radioactive) waste or transuranic (TRU) waste.

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- Availability of necessary equipment and specialists and provisions to provide any necessary additional resources

- Availability of services and materials plus the potential for obtaining competitive bids, which may be particularly important for innovative technologies

- Availability of prospective technologies

The impact of reasonable deviations on the implementability of each alternative and the availability of contingency plans to handle the deviations must be addressed in the evaluation. Implementability is a balancing criterion that must be considered.

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- **<u>Cost</u>**. Site characterization and treatability investigation information should permit the user to refine cost estimates for remedial action alternatives. Typically, these study estimates are expected to provide an accuracy of plus 50 to minus 30 percent based on the existing information. A present worth analysis is used to evaluate expenditures that occur over different time periods by discounting all future costs to a common base year, usually the current year. This allows the cost of remedial action alternatives to be compared on the basis of a single figure representing the amount of money that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life. In conducting the present worth analysis, assumptions must be made regarding the discount rate and the period of performance. Federal policy recommends assumption of a discount rate of 7 percent after inflation. Estimates of costs in each of the planning years are made in constant dollars, representing the general purchasing power at the time of construction. In general, the period of performance for costing purposes should not exceed 30 years because subsequent years contribute very little to the final present worth dollars. A comprehensive discussion of costing procedures for CERCLA sites is contained in the *Remedial Action Costing Procedures Manual* (EPA, 1985). The application of cost estimates to the detailed analysis is discussed in the following paragraphs. The base action and the contingent actions are costed along with the monitoring plan.

  - Capital Costs. Capital costs consist of direct (construction) and indirect (nonconstruction and overhead) costs. Direct costs include expenditures for the equipment, labor, and materials necessary to implement remedial actions. Indirect costs include expenditures for engineering, financial, and other services that are not part of actual installation activities, but are required to complete the installation of remedial alternatives. (Sales taxes normally do not apply to Superfund actions.) Costs that must be incurred in the future as part of the remedial action alternative should be identified and noted for the year in which they will occur. The distribution of costs over time will be a critical factor in making tradeoffs between capital-intensive technologies (including alternative treatment and destruction technologies) and less capital-intensive, but more O&M intensive, technologies (such as pump and treatment systems).

  - Annual Operations and Maintenance (O&M) Costs. Annual O&M costs are post-construction costs necessary to provide continued effectiveness of a remedial action. The following O&M cost components should be considered:

    - Labor costs

    - Maintenance, services, materials, and energy costs

    - Disposal of residues. Costs to treat or dispose of residuals, such as sludges from treatment processes or spent activated

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- Administrative costs. Costs associated with the administration of remedial O&M not included under other categories

- Insurance, taxes, and licensing costs. Costs of such items as liability and sudden accidental insurance, real estate taxes on purchased land or rights-of-way, licensing fees for certain technologies, and permit renewal and reporting costs

- Rehabilitation costs. Cost for maintaining equipment or structures that need repair

- Costs of periodic site reviews. Costs for site reviews that are conducted at least every 5 years if wastes above health-based levels remain at the site

- After the present worth of each remedial action alternative is calculated, individual costs may be evaluated through a sensitivity analysis if there is sufficient uncertainty about specific assumptions. The results of the analysis may lead to consideration of which assumptions may require contingent actions.

Almost any reasonable deviation, if encountered, can be expected to have an impact (e.g., increasing costs) on total cost of a remedial action. As each contingency plan is discussed during the individual analyses of the alternatives, the potential cost impacts of the contingency plan should be addressed. The cost estimate for a contingency plan does not need to meet the plus 50 to minus 30 percent accuracy required for cost estimates for the (base) alternatives. The reasonable deviation is not likely to be encountered (otherwise it would be the probable condition) or the contingency plan implemented. The effort spent in defining or estimating costs for contingency plans should be commensurate with the following factors:

- the likelihood of the occurrence of the reasonable deviation

- the lead-time available to implement the contingency plan if the reasonable deviation occurs

- the impact on cost, implementability, and other related factors by delaying definition or estimating costs of the contingency plan

The impact of reasonable deviations on the cost of each alternative and the cost impacts of contingency plans to handle the deviations must be addressed in the evaluation. The cost presented for each alternative should include separately the costs of the contingency plans and the probability of implementing each contingency plan. The probabilities do not have to be

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quantitative; they can be subjective statements of likelihood based on best professional judgment. Cost, including cost of potential contingencies, is a balancing criterion that must be considered.

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<u>Note B</u>. **<u>Example Summary of Individual Analysis of Alternatives</u>.** This note provides an example summary of an individual analysis in tabular form. More detailed discussion was provided in the narrative in the FS, which is not included here. The comparative analysis is for the Warm Springs Ponds OU of the Silver Bow Creek NPL site in Montana. The Warm Springs Ponds are located 17 river miles below massive mining and milling operations in Butte, Montana. They precipitated more than 20 million cubic yards of heavy-metal-bearing tailings out of flows in Silver Bow Creek during nearly a century of mining operations. The berms that contain the man-made ponds were unstable to moderate earthquakes or moderate floods. A catastrophic release of the tailings in the ponds would contaminate miles of the Clark Fork River, a major fishery, downstream. The alternatives address four major site problems:

- The 20 million cubic yards of toxic sediments in the ponds
- The need for continuing treatment of the contaminated flows in Silver Bow Creek
- Exposed contaminated tailings along creek banks that cause recurrent major fishkills in the Clark Fork River
- A groundwater plume of limited extent just downgradient of the pond

The alternatives range in cost from $55 million to nearly $1.7 billion.

This analysis is structured around the criteria specified in the NPL, but also shows in further breakout the factors that should be considered under each criterion as given in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988). This facilitates reviewing the analysis for completeness.

The ARARs analysis for this site was very complex and could not be easily summarized in the table. The full text of the ARARs analysis is more than 200 pages long, which is the reason little information is provided here on ARARs.

Contingency plans would not be presented in the individual analysis table because they are developed and evaluated against a more limited set of criteria–implementability, protectiveness, and cost (see Submodule 4.4, Note A, and Submodule 5.1). The contingency plan would be mentioned in the individual analysis table only if the contingency plan had a significant chance of being implemented, and its implementability, protectiveness, or cost would be significantly different from the base alternative, potentially changing the evaluation of these criteria for the base alternative. Instead, contingency plans should be addressed in the narrative of the individual analysis.

This tabular note has been edited and is provided for illustrative use. Alternatives 4 and 6 have been intentionally omitted from this example, which was taken from *Silver Bow Creek Investigation, Feasibility Study for the Warm Springs Ponds Operable Unit* (Montana Department of Health and Environmental Services, 1989).

Table

Summary of Individual Analysis of Alternatives

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Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 5	Alternative 7
Description	Solidify pond sediments; remove soils from bypass; construct a new treatment pond and a flood impoundment of 8,000 acre-feet; excavate contaminated soil with pond disposal and solidification; groundwater collection with treatment in new pond.	Stabilize pond berms against PMF and MCE; remove soils from bypass; upgrade treatment system; add flood impoundment of 8,000 acre-feet; excavate contaminated soil with offsite disposal; groundwater collection with treatment in Pond 3.	Stabilize pond berms against a partial PMF and the MCE; remove soils from bypass; upgrade treatment system; add settling basin of 2,000 acre-feet; excavate contaminated soil with Pond 1 disposal; cap Pond 1; groundwater collection with treatment in Pond 3.	Stabilize pond berms against a partial PMF and MCE; remove soils from bypass; modify treatment system; add settling basin of 2,000 acre-feet; cap and revegetate contaminated soils; groundwater collection with wetlands treatment.	No action.
Overall Protectiveness					
Pond Bottom Sediments	Risks reduced through solidification of sludges and sediments.	Risks reduced through stabilization of pond berm against threat of failure.	Risks reduced through stabilization of pond berms against moderate cases.	Same as Alternative 3.	No reduction in risk; threat of pond failure increases with time.
Surface Water	New treatment pond and flood impoundment pond would provide improved water quality through enhanced treatment for all flows.	Upgraded treatment and flood impoundment pond would provide improved water quality through enhanced treatment for all flows.	Upgraded treatment pond and new settling pond would provide improved water quality. All flows less than 600 cfs and the first 2,000 acre-feet of flows greater than 600 cfs treated for suspended and dissolved metals. Remaining flows treated for suspended solids only.	Modified treatment system and new settling pond would provide improved water quality for up to 210 cfs and the first 2,000 acre-feet of flows greater than 210 cfs. Flows above 120 cfs treated for suspended solids only.	No improvement in water quality. Frequent violations and periodic fishkills.
Tailings Deposits and Contaminated Soils	Risks reduced through excavation and solidification.	Risks reduced through excavation and offsite disposal at a RCRA TSDF. No treatment prior to disposal.	Risks reduced through excavation and disposal under a RCRA-equivalent cap. No treatment prior to disposal.	Same as Alternative 4.	No reduction in risk of migration or exposure.
Groundwater	Collection with treatment in a new treatment pond reduces risk of exposure and migration	Collection with treatment in Pond 3 reduces risk of exposure and migration.	Same as Alternative 2.	Collection with onsite wetlands treatment reduces risk of exposure and migration in groundwater, but increases risk of contamination of wetlands biota, sediment, and soils.	No reduction in risk of migration or exposure.
Compliance with ARARs					
Chemical-specific, Location-specific, and Action-specific	See Table 8-4.	See Table 8-4.	See Table 8-4.	See Table 8-4.	See Table 8-4.

Note B: Example Summary of Individual Analysis of Alternatives (continued)

Summary of Individual Analysis of Alternatives

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Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 5	Alternative 7
Long-Term Effectiveness and Performance					
Residual Risk	All present risks reduced; residual risks result from deposition of tailings and sludges in the new treatment and flood impoundment ponds.	All present risks addressed; residual risks result from unsolidified sludges in Ponds 1 and 2, and the continuous deposition of tailings and sludges in the flood impoundment and Pond 3.	All present risks addressed; residual risks result from extreme floods, unsolidified sludges in Pond 2, capped sludges in Pond 1, the continued deposition of tailings and sludges in the settling basin and in Pond 3, large quantity of capped material around the site, and the discharge without dissolved metals treatment of flows greater than 600 cfs and 2,000 acre-feet.	All present risks addressed; residual risks result from extreme floods, unsolidified sludges, continued use of Pond 2 during high flows, continued deposition of tailings and sludges in Pond 3 and tailings in the settling pond, large quantity of capped material around the site, and the discharge without dissolved metals treatment of flows greater than 210 cfs and 2,000 acre-feet.	All present risks remain unmitigated.
Adequacy and Reliability of Controls	In situ solidification of sludges is unproven and because of sludge volume solidification could take up to 14 years. Remaining controls are adequate to manage risks and are reliable with proper design, construction, operation, and maintenance.	All controls adequate and reliable for stated purpose. O&M required to maintain reliability.	All controls adequate and reliable for stated purpose. O&M required to maintain reliability.	Wetlands treatment of extracted groundwater is an innovative, underdeveloped process. The adequacy and reliability of wetlands treatment cannot be stated with certainty. Other controls are adequate and reliable for their stated purpose. O&M required to maintain reliability. Modifications to pond treatment system may not be adequate to consistently achieve discharge standards.	Inadequate to achieve remedial action objectives for the operable unit.
Reduction of Toxicity, Mobility, and Volume	Solidification of sludges directly reduces mobility of pond bottoms. New treatment ponds reduce toxicity of surface water. Excavation and solidification of soils and tailings reduces mobility. Groundwater collection and treatment reduces mobility and toxicity.	Stabilization of pond berms reduces mobility of pond bottoms for all cases. Upgraded treatment system and flood impoundment reduce toxicity of surface water. Excavation and offsite disposal of soils and tailings reduces their mobility. Groundwater collection and treatment reduces toxicity.	Stabilization of pond berms reduces mobility of pond bottoms for all but extreme cases. Upgraded treatment system and settling basin reduce toxicity of surface water. Excavation and onsite disposal of tailings reduces their mobility. Groundwater collection and treatment reduces mobility and toxicity.	Stabilization of pond berms reduces mobility of pond bottoms for all but extreme cases. Modified treatment system and settling basin reduces toxicity of surface water. Capping tailings in place will reduce their mobility. Groundwater collection and treatment in wetlands reduces mobility and toxicity of groundwater, but increases toxicity of wetland biota, sediment, and soils and may result in recontamination of groundwater.	No reduction of toxicity, mobility, or volume.

Summary of Individual Analysis of Alternatives

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Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 5	Alternative 7
Short-Term Effectiveness					
Protectiveness	No increased risk to community during remediation. Protection of workers against dermal contact and inhalation of tailings dust required in tailings contaminated areas.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Threat of pond failure increases with time. Other risks remain unchanged.
Environmental Impacts	Significant habitat alteration as a result of pond solidification and construction of new ponds. 1,200 acres of wetlands and open water habitat destroyed. Up to 600 acres of open water habitat created by new treatment pond. Potential for airborne release of tailings during implementation. Upstream flood impoundment will permanently alter up to 1,000 acres of rangeland. Planning required to prevent affecting a pair of bald eagles sighted within the operable unit. Solidification would remove 1,000 acres of eagle feeding area.	Some temporary habitat alteration will occur during remediation. Only the upstream flood impoundment and capping Pond 1 will permanently alter up to 1,000 acres of rangeland. Potential for airborne release of tailings during implementation. Treatment of bypass flows in the pond system will dry up a portion of the bypass during all flows less than a 100-year flood (up to 4,000 cfs, eliminating an established catch and release fishery). Planning required to prevent affecting a pair of bald eagles sighted within the operable unit.	Same as Alternative 2, except upstream settling basin will alter significantly less rangeland (500 acres vs 1,000 acres) than the flood impoundment. Planning required to prevent affecting a pair of bald eagles sighted within the operable unit.	Same as Alternative 4, except the bypass will only be affected during flows of less than 210 cfs or above 210 cfs but under 2,000 acre-feet. Planning required to prevent affecting a pair of bald eagles sighted within the operable unit.	Continued impacts from existing conditions.
Time Until Completion	Approximately 17 years	Three to four construction seasons.	Two to three construction seasons.	Two to three construction seasons to complete. Startup of wetlands systems may take 5 years.	Not applicable.

Summary of Individual Analysis of Alternatives

Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 5	Alternative 7
Implementation, Reliability, Constructibility					
Ability to construct and operate	In situ solidification process is an innovative technology with no past remediation experience. The effectiveness of the process for remediation is unknown. It has been used in Japan for swamp stabilization. Other components are feasible, implementable, and reliable for their stated objective. Land acquisition for the flood impoundment may prove difficult.	All components are feasible, implementable, and reliable for their stated objective. Availability of adequate riprap is unknown. Land acquisition for the flood impoundment may prove difficult.	Same as Alternative 2, except land acquisition for settling basin may prove less difficult than for the flood impoundment.	Wetlands treatment system is an innovative technology. It has been used with varying degrees of success. May require extensive startup time. Long-term reliability cannot be fully assessed. All other components are feasible for their stated objective. Availability of adequate riprap is unknown. Land acquisition for the settling basin may prove difficult.	Not applicable.
Permits Required	NPDES permit required for pond discharge.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Monitoring Requirements	Surface water and groundwater monitoring required for compliance.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Ongoing surface water monitoring as required per NPDES permit.
Costs					
Capital	$1,679 million	$261 million	$71 million	$66 million	--
Annual O&M	$283,000	$301,000	$300,000	$284,000	--
Present Worth	$1,191 million	$241 million	$71 million	$66 million	--

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Note C. **ARARs Waivers**. According to NCP Section 300.430 (f)(i)(2)(c), an alternative that does not meet ARARs can still be selected for implementation under the following circumstances:

1. The action is an interim measure and will become part of a total remedial action that will attain ARARs.

2. Compliance with the requirement will result in greater risk to human health and the environment.

3. Compliance with the requirement is technically impracticable.

4. The alternative will attain a standard of performance that is equivalent to that required through use of another method or approach.

5. The state has not consistently applied or demonstrated the intention to consistently apply the promulgated requirement in similar remedial actions at other sites within the state.

Note that a sixth ARARs waiver available to EPA Superfund-financed response actions, commonly referred to as "fund-balancing," is not applicable to DOE facilities because the remediations at DOE sites are not funded through the CERCLA Trust Fund.

EPA's *CERCLA Compliance with Other Laws Manual* provides additional information on each of these grounds for invoking a waiver.

Submodule 6.2, Note B, provides example language for documenting ARARs waivers in the ROD.

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Note D. **Example Summary of Comparative Analysis of Alternatives.** This note provides an example comparative analysis from the Warm Springs Ponds FS. The individual analysis summary table is shown in Submodule 5.2, Note B. The comparative analysis is structured around the evaluation criteria given in the NPL. Unlike the individual analysis, which focuses on the alternatives, the comparative analysis focuses on the differences and tradeoffs between the alternatives. The differences in performance against the criteria often are quite significant. In this FS, the alternatives were developed to provide a large range of variability among the alternatives in meeting the evaluation criteria. Cost, in particular, varies significantly among the alternatives, but protectiveness and long-term effectiveness also vary substantially. The largest differences derive from varying levels of continuing treatment provided for the contaminated flows in Silver Bow Creek.

As with the individual analysis, the contingency plans are not mentioned in the comparative analysis table. The contingency plan would be mentioned in the comparative analysis table only if a contingency plan had a significant chance of being implemented and its implementability, protectiveness, or cost would be significantly different from the base alternative, potentially changing the evaluation of these criteria for the base alternative.

This tabular note has been edited and is provided for illustrative use. This example was selected because the magnitude of the waste volume and the low-threat status involve site conditions similar to those that will be addressed by DOE. The example was taken from *Silver Bow Creek Investigation, Feasibility Study for the Warm Springs Ponds Operable Unit* (Montana Department of Health and Environmental Services, 1989).

Summary of Comparative Analysis of Alternatives[a]

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Overall Protectiveness	Long-Term Effectiveness	Reduction of Toxicity, Mobility, and Volume	Short-Term Effectiveness	Implementability	Cost
All alternatives except 6 and 7 address all of the identified ARARs and human health concerns. Alternative 1 is the most protective in terms of the pond bottom sediments because it includes solidification as treatment. Alternative 2 protects the pond berms more than the remaining alternatives (full PMF vs partial PMF). Alternatives 1 and 2 provide the greatest level of treatment for surface and groundwater. Alternatives 3 and 4 are not as protective for flows >600 cfs. Alternatives 5 and 6 only provide improved treatment for average flows. Alternative 1 is the most protective against tailings and contaminated soils by providing treatment. Alternative 2 removes the risk from the site but does not treat the material. Alternatives 3, 4, and 5 cap the material onsite, but Alternative 3 is the most protective because it consolidates the material.	Alternative 1 has the least residual risk through the treatment of tailings, sludges, and sediments. Threats associated with the presence of untreated tailings and sediments are minimized. Alternative 2 has the least residual risk of the alternatives that do not eliminate the current pond system because it protects the ponds against a full PMF. The remaining action alternatives are equal in terms of controlling residual risk from the pond sediments. They all protect the ponds against a full MCE and a partial PMF. They differ in the level of water treatment. The risk of untreated water flowing out of the operable unit increases with each alternative from 3 to 7. The onsite residual risks from contaminated soils and tailings are minimized in Alternatives 1 and 2. Alternative 3 reduces the residual risk by consolidating the material. Alternative 6 contains the greatest residual risk of the action alternatives because of a lack of treatment for surface water flows above 120 cfs and the potential mobility of tailings and soils onsite.	Only Alternative 1 includes treatment of pond bottoms as part of the remediation. The remaining action alternatives limit the mobility of the sediments. No alternative addresses the volume of pond bottom sediments. Alternatives 1 and 2 provide the greatest reduction in toxicity and volume of contaminated surface and groundwater. Alternatives 3, 4, 5, and 6 treat portions of the water flow to reduce its toxicity and the volume of contaminants, but with decreasing effectiveness. Alternative 6 provides the least reduction in surface water toxicity, improving treatment only for average and less-than-average flow out of the operable unit. Alternative 1 treats the tailings and contaminated soils at the site to reduce their mobility. The remaining alternatives contain actions to reduce the mobility of the material, but they do not include direct treatment. Alternative 2 removes the material from the site. Alternative 3 provides the best onsite containment using consolidation and a RCRA-equivalent cap.	None of the alternatives will significantly affect the Warm Springs community during implementation. It is likely that construction in the tailings and contaminated soil would result in some local airborne releases of the material, but this is not expected to affect the town of Warm Springs. Remediation contractors would have to be protected against dermal and inhalation threats while working in areas containing tailings and contaminated soils. These threats could be controlled using masks and protective clothing. This applies to all alternatives. All six action alternatives will require planning to protect a pair of bald eagles living within the operable unit. Only Alternative 1 would substantially impact potential eagle habitat. Alternative 1 would take about 17 years to complete because of the large volume of pond sediments requiring solidification. The remainder of the alternatives would take 2 to 5 years to complete. The wetlands system included in Alternatives 5 and 6 may take up to 5 years of startup to meet the operational objectives.	The majority of components proposed for the alternatives are well developed and expected to be easily implemented at the Warm Springs Ponds site. This includes all pond berm stabilization, groundwater collection, surface and groundwater treatment, and soils excavation and/or containment. In situ solidification (Alternative 1) and wetlands treatment (Alternatives 5 and 6) are innovative technologies much less developed and predictable than the other components. In situ solidification has not been used for waste stabilization, and its effectiveness, completeness, and permanence are not known for certain. Pilot tests would be required prior to initiation to verify its feasibility. Wetlands treatment has been used with varying degrees of success in treating acid mine drainage. Based on those results, its use here is expected to be feasible, although the startup period needed to establish good operation may require up to 5 years.	Annual operation and maintenance costs are almost equal (about $300,000) for the six action alternatives. Present worth costs are as follows: Alt. 1 – $1.19 billion Alt. 2 – $241 million Alt. 3 – $71 million Alt. 4 – $77 million Alt. 5 – $66 million Alt. 6 – $55 million Alt. 7 – the no-action alternative, has no costs beyond existing operations.

Note D: Example Summary of Comparative Analysis of Alternatives (continued)

Summary of Comparative Analysis of Alternatives[a]

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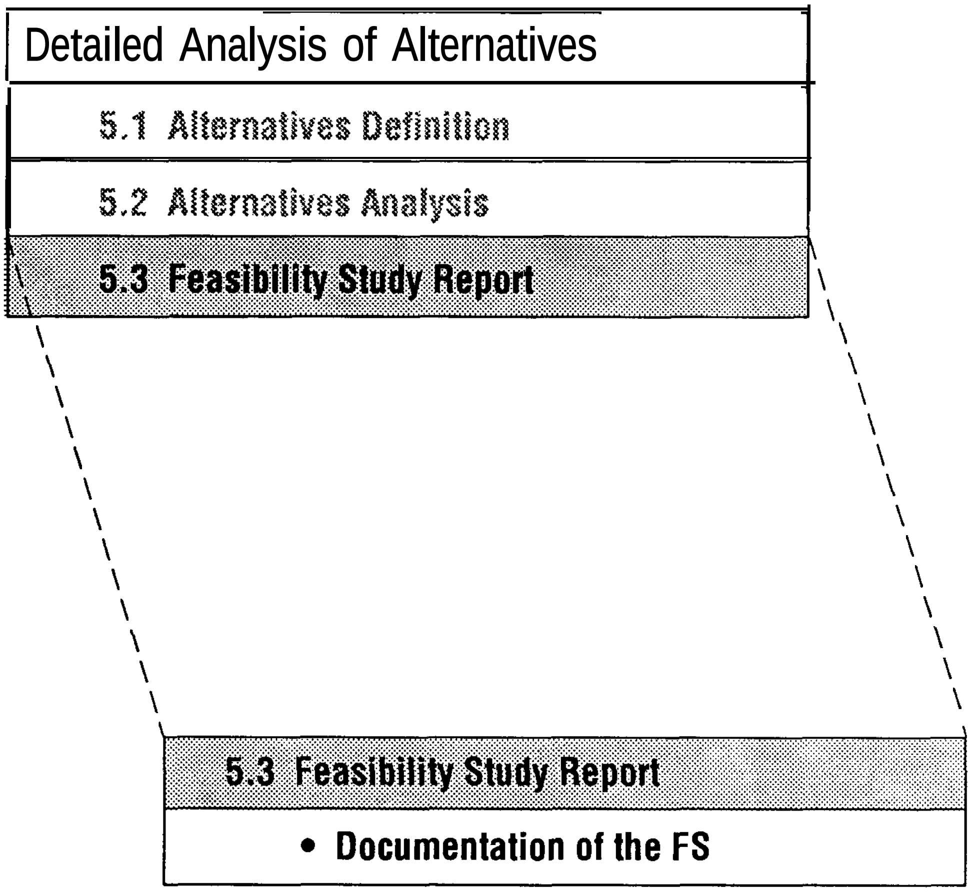
Overall Protectiveness	Long-Term Effectiveness	Reduction of Toxicity, Mobility, and Volume	Short-Term Effectiveness	Implementability	Cost
Alternative 6 is the least protective of the action alternatives, isolating the material through flooding but not permanently treating or immobilizing it.	Operations, maintenance, and monitoring requirements would be fairly equal for all six action alternatives because of similar surface and groundwater treatment schemes for all alternatives. All six action alternatives would require continued surface and groundwater monitoring. The majority of O&M tasks are related to operation of the surface water treatment system, a component present in all alternatives. The wetlands treatment system (Alternative 5 and 6) will increase O&M during startup, but this will decrease once the system is operating to design specifications. Permanence is greatest for most comprehensive actions (e.g., solidification and flood impoundment).		Alternative 1 would have a greater impact on the surrounding environment than any of the other alternatives because of the replacement of the present pond system. This would eliminate a substantial amount of wetland habitat. The remaining alternatives would temporarily affect the wetland habitat, but it would, for the most part, be restored. All six action alternatives would convert rangeland habitat to a flood impoundment or settling pond. The settling pond (Alternatives 3-6) would alter less land (500 acres vs 1,000 acres) than the flood impoundment. Alternatives 5 and 6 would increase the wetland habitat onsite through the construction of a wetlands treatment system.	All seven alternatives need an NPDES permit for pond discharge. The equipment and materials required for the majority of the components are readily available. The exceptions are the machinery needed for in situ stabilization (4 to 6 months to fabricate), and an adequate supply of riprap. The riprap may have to be quarried specifically for this job, which is a feasible alternative.	

[a]Compliance with ARARs is covered in Table ES-13.

Submodule 5.3 Feasibility Study Report



Submodule 5.3 Feasibility Study Report

Background

The FS report is the only required document during the FS. The FS report provides the decisionmakers with the information to make an informed selection of a remedial action. It also provides the basis for the ROD and communicates the implementation and outcome of the FS process to stakeholders. Preparation of technical memoranda during the FS process, summarizing the results of early stages, enables frequent communication with the stakeholders. A technical memorandum at the conclusion of alternatives development can provide information to the decisionmakers to allow them to make final modifications to or determinations about ARARs.

Organization

Submodule 5.3 discusses the following:

- Documentation of the FS

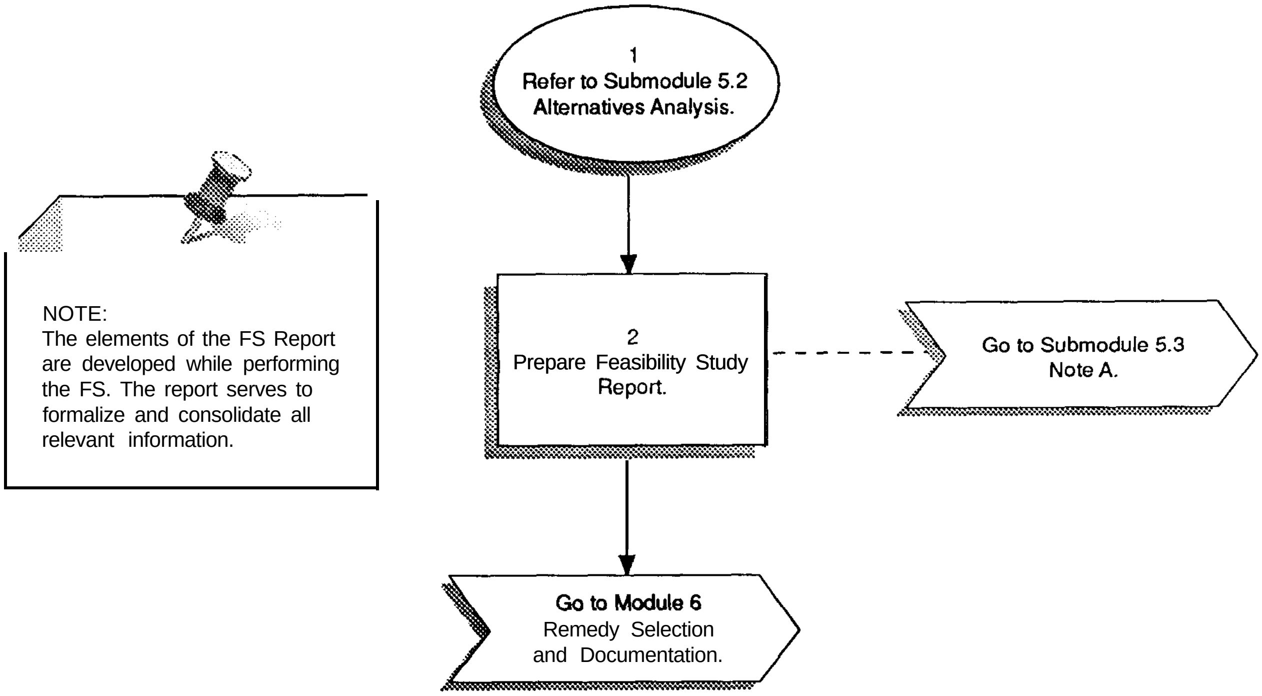
In addition, more detailed information is provided in the following note:

- Note A–Suggested FS Report Format

Sources

1. U.S. EPA, October 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, Interim Final, EPA/540/G89/004, OSWER Directive 9356.3-01.

Subtnodule 5.3 Feasibility Study Report



Step 1. Refer to Submodule 5.2, Alternatives Analysis.

Step 2. **Prepare FS report**. Preparing the FS report is largely a matter of assembling the materials previously prepared as a part of conducting the FS (Modules 4 and 5). The following documentation should be available:

- Summarized background information from the RI report. A good executive summary of an RI report would serve this purpose
- Development of preliminary remediation goals (PRGs) and remedial action objectives (RAOs)
- Identification and screening of general response alternatives (GRAs), technologies, and process options
- Assembly and preliminary definition of alternatives
- Screening of alternatives, if performed
- Detailed definition of alternatives
- Individual analysis of alternatives

In addition, the following documents will have to be written:

- ARARs analysis based on close interaction with the regulatory agencies
- Transitional or explanatory materials between FS chapters, as required

Submodule 5.3, Note A provides an example outline for an FS report.

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Note A. **Suggested FS Report Format**

Executive Summary

1. Introduction
   - 1.1 Purpose and Organization of Report
   - 1.2 Background Information (Summarized from RI Report)
     - 1.2.1 Site Description
     - 1.2.2 Site History
     - 1.2.3 Nature and Extent of Contamination
     - 1.2.4 Contaminant Fate and Transport
     - 1.2.5 Baseline Risk Assessment

2. Identification and Screening of Technologies
   - 2.1 Introduction
   - 2.2 Remedial Action Objectives

     Presents the development of remedial action objectives for each medium of interest (e.g., groundwater, soil, surface water, air). For each medium, the following should be discussed:

     - Contaminants of interest
     - Allowable exposure based on risk assessment (including ARARs)
     - Development of remediation goals

   - 2.3 General Response Actions

     For each medium of interest, describes the estimation of areas or volumes to which treatment, containment, or exposure technologies may be applied

   - 2.4 Identification and Screening of Technology Types and Process Options–For each medium of interest describe:
     - 2.4.1 Identification and Screening of Technologies
     - 2.4.2 Evaluation of Technologies and Selection of Representative Technologies

3. Development and Screening of Alternatives
   - 3.1 Development of Alternatives

     Describes rationale for combination of technologies/media into alternatives. Note: The discussion may be by medium or for the site as a whole.

   - 3.2 Screening of Alternatives (if conducted)
     - 3.2.1 Introduction
     - 3.2.2 Alternative 1
       - 3.2.2.1 Description
       - 3.2.2.2 Evaluation

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3.2.3 Alternative 2
3.2.3.1 Description
3.2.3.2 Evaluation
3.2.4 Alternative 3, etc.

4. Detailed Analysis of Alternatives
4.1 Introduction
4.2 Individual Analysis of Alternatives
4.2.1 Alternative 1
4.2.1.1 Description
4.2.1.2 Assessment
4.2.2 Alternative 2
4.2.2.1 Description
4.2.2.2 Assessment
4.2.3 Alternative 3
4.3 Comparative Analysis

Bibliography

Appendices

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